KHORLOCHHU HYDRO POWER LIMITED

4x150 MW KHORLOCHHU HYDROPOWER PROJECT

TRASHIYANGTSE; BHUTAN

BIDDING DOCUMENT

FOR

CONTRACT PACKAGE: KEM-1

DESIGN, MANUFACTURING, SUPPLY, INSTALLATION, TESTING AND COMMISSIONING OF ELECTRO-MECHANICAL WORKS

VOLUME - 1

INSTRUCTIONS TO BIDDERS (ITB)

International Competitive Bidding

These documents are meant for the exclusive purpose of bidding against this NIT and shall not be transferred, reproduced or otherwise used for purposes other than that for which they are specifically issued.

Tender Ref. No. KHPL/C&PD/TENDER:KEM-1/2025/11534 dt. 07.08.2025

LAYOUT OF BIDDING DOCUMENTS
CONTRACT PACKAGE: KEM-1
Design, Manufacturing, Supply, Installation, Testing and Commissioning of Electro-Mechanical Works

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- Section - 2 Instructions to Bidders (ITB), Bid Data, Qualification Forms, Information for Bidders (IFB) and Work Schedule

Volume - 2: General Conditions of Contract (GCC) and Particular Conditions of Contract (PCC)

- Section - 3 FIDIC General Conditions of Contract (GCC) for Plant and Design-Build Contract (First Edition 1999)
- Section - 5 Forms and Procedures
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  - Form-8: Dispute Adjudication Agreement
  - Form-9: Parent/Holding Company Agreement
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Volume-3: Price Schedules

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- Section - 6 General Technical Specifications (GTS)
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ABRIDGED NOTICE INVITING TENDER

Ref. No.: KHPL/C&PD/TENDER:KEM-1/2025/11534 **August 07, 2025**

Khorlochhu Hydro Power Limited (KHPL) invites sealed bids through International Competitive Bidding Process from an experienced, reputed, competent and financially sound Bhutanese/Indian Bidders registered in Bhutan/India and meeting the minimum qualification criteria for the works as mentioned below for **4x150MW Khorlochhu Hydropower Project** located under Trashiyangtse Dzongkhag, Bhutan, as follows:

Contract Package No.	Description of Work	Bid Security (BTN/INR)	Time for Completion in Months
KEM-1	Design, Manufacturing, Supply, Installation, Testing and Commissioning of **Electro-Mechanical Works** of 4x150MW Khorlochhu Hydropower Project.	180.00 million	42 Months
KHM	Design, Manufacturing, Supply, Installation, Testing and Commissioning of **Hydro-Mechanical Works** of 4x150MW Khorlochhu Hydropower Project.	90.00 million	42 Months

The complete set of Bidding Document can be downloaded from following websites www.khpl.bt and www.drukgreen.bt. Amendment(s), if any, shall be issued by KHPL in the above websites only.

The Bidding Documents shall be made available from **August 08, 2025, till October 17, 2025**, and it can be downloaded from the above websites (free of cost) during the period. However, the Bidders should register with KHPL before the deadline for submission of Bids.

KHPL reserves the right to cancel or annul the whole bidding process without assigning any reasons thereof. For further queries, kindly contact KHPL at Mobile No. 17289767/17625818, during office hours only.

General Manager,
Contracts & Procurement Division,
Khorlochhu Hydro Power Limited,
Post Box No. 46002,
Doksum New Township, Trashiyangtse, Bhutan

NOTICE INVITING TENDER

Ref. No.: KHPL/C&PD/TENDER:KEM-1/2025/11534 August 07, 2025

1) Khorlochhu Hydro Power Project (KHPL) invites sealed Bids from eligible Bidders through Single-Stage Process Two Envelope Method meeting the qualification requirements for procurement of "Contract Package KEM-1: Design, Manufacturing, Supply, Installation, Testing and Commissioning of Electro-Mechanical Works" as per the scope of works mentioned hereinafter.

2) The scope of work comprises the design, manufacturing, supply, installation, testing and commissioning of Electro-Mechanical Works of 4x150MW Khorlochhu Hydropower Project.

3) Detailed specifications, scope of works and terms & conditions are provided in the Tender Documents, which are available as per the following schedule:

NIT No.	:	KHPL/C&PD/TENDER:KEM-1/2025/11534 dated August 08, 2025
Bidding Document availability date	:	From August 08, 2025, to October 17, 2025
Bid Receipt Date and Time Place	: :	Up to 17/10/2025 by 10:30 AM (BST) Corporate Office, KHPL, Doksum New Township, Trashiyangste
Pre-Bid Meeting Date and Time Place	: :	From 09/09/2025 to 11/09/2025 Corporate Office, KHPL, Doksum New Township, Trashiyangste
Bid Opening Date and Time Place	: :	17/10/2025 at 11:30 AM (BST) Corporate Office, KHPL, Doksum New Township, Trashiyangste

4) Bidding Documents shall be downloaded from the websites (www.khpl.bt) and www.drukgreen.bt (free of cost). Bidders downloading the documents from the website should register themselves by informing the nodal officer of KHPL immediately after the documents are downloaded, or before the deadline for submission of Bid and their intention to submit the Bid.

5) Downloading of Bidding Documents shall not automatically construe that the Bidder fulfils the Qualifying Requirements which shall be determined during Bid evaluation based on data/documents submitted by the Bidder. Bids shall be submitted at the address given below and shall be opened in the presence of Bidder's representatives who choose to attend.

6) All Bids must be accompanied by Bid Security for an amount of **BTN/INR 180.00 million (Bhutanese Ngultrum/India Rupees One Hundred Eighty Million)** only, in the form of Demand Draft /Cash Warrant/Bank Guarantee, issued by any Financial Institutions of Bhutan or any foreign bank acceptable and enforceable by any financial institution of Bhutan and shall remain valid till May 15, 2026. Bids not accompanied with an acceptable Bid Security as specified in the Bidding Documents or Bids accompanied with Bid Security of inadequate value and validity shall be rejected by KHPL and in such cases Bids shall be returned to the Bidders.

7) Qualification Requirements for Bidders shall be as specified in the BDS.

8) The Bidder shall be a single entity for participation in the tendering for this Project. Detail of the nature of Bidder are specified in the Bidding Documents. The Bidders not having requisite specific experience can associate Sub-contractor(s) for specified activities in which

he does not have relevant experience. The proposed Sub-Contractor(s) shall individually meet at least one or more of the Specific Experience.

9) Bidders must submit the copies of

   (i) latest Tax Clearance Certificate & Trade License & CDB Registration Certificate (for Bhutanese Bidders);

   (ii) Certificate of Incorporation in case of companies or any other certificate as an evidence of being a legal entity (for International Bidders) and

   (iii) Signed Integrity Pact statement as per the format provided in the Bidding Documents along with their Bid.

10) The Bidders shall be required to attain the Completion of Works within the time for completion as specified in the PCC.

11) The Employer reserves the right to accept or reject any or all Bids without assigning any reasons thereof and in such case no Bidder shall have any claim arising out of such action of the Employer.

12) The address for communication is:

General Manager,
Contracts & Procurement Division,
Khorlochhu Hydro Power Limited
Postal Box. No. 46002,
Doksum New Township, Trashiyangtse, Bhutan
Email: gm.cnp@khpl.bt Website: www.khpl.bt

INSTRUCTIONS TO BIDDERS (ITB)

A. General

1. Scope of Bid

1.1 The Khorlochhu Hydro Power Limited (KHPL), having its registered office at Trashiyangtse, Bhutan, hereinafter referred to as "the Employer", invites bids for the Electro-Mechanical Works Package KEM-1, as described in this Bidding Documents and summarized in the Bid Data Sheet, hereinafter referred to as "the Works"

1.2 The successful bidder will be required to complete the 'Works' within the period stated in the 'Bid Data Sheet' and 'Appendix to Tender' effective from the Commencement Date.

1.3 Throughout these Bidding Documents, the terms bid and tender and their derivatives (bidder/tenderer, bid/tender, bidding/tendering etc.) are synonymous; day means calendar day; singular also means plural, unless these are repugnant to the context.

2. Source of Funds

2.1 The Project financing will be done through 30% equity contribution by Shareholders through a strategic partnership between Druk Green Power Corporation (DGPC), Bhutan and Tata Power Company Limited (TPCL), India in the ratio of 60:40. The 70% debt portion will be raised through a debt financing from Power Finance Corporation Limited (PFC), India.

3. Eligible Bidders

3.1 This invitation to bid is open to all experienced, reputed, competent and financially sound Indian and Bhutanese Contractors who meet the Qualification Criteria as per ITB Clause-5 [Qualification of the Bidder] hereunder.

3.2 Bidders should not have been under the status of banned/ de-listed/ blacklisted/ debarred from business by the Employer or any Government institution or public sector enterprise or any Government, as on the time of bid submission deadline. A declaration to this effect shall be submitted under **Attachment-3 of Form-1: Letter of Tender appended under Section-5 of Volume 2**.

3.3 The Integrity Pact, signed by all the prospective Bidders and the Employer, shall commit the persons/officials of both the parties, not to exercise any corrupt/ fraudulent/ collusive/ coercive practices in the tendering process and also during implementation of the Contract. Only those bidders who have entered into Integrity Pact with the Employer shall be eligible to participate in the bidding process. Entering into Integrity Pact, as per **Attachment-5 under Section-5 of Volume 2** of Bidding Documents is a basic qualifying requirement.

The form of Integrity Pact included in the Bidding Documents, duly signed by authority by authorized representative of Employer at the time of issue of Bidding Documents, shall be signed by the Bidder while submitting the bid. Signing authorities will be the representative of Bidder authorized to sign the bid and the authorized representative of the Employer.

The successful Bidder shall submit duly executed Integrity Pact on Legal stamp of the Royal Government of Bhutan (RGoB) of appropriate value prior to signing of Contract Agreement.

3.4 Bidders do not and will not appoint **Local** agents in Bhutan. A declaration to this effect shall be submitted under **Attachment-3 of Form-1: Letter of Tender appended under Section-5 of Volume 2**.

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4. Eligible Materials, Plant, Supplies, Equipment and Services

4.1 The materials, Plant or Contractor's Equipment, other supplies, and services to be provided under the contract, shall have their origin in eligible source countries, defined under the Bidding Document and all expenditures made under the contract will be limited to such materials, Plant or Contractor's Equipment, other supplies, and services.

4.2 For purposes of Sub-Clause 4.1 above, origin means the place where the materials, plant, equipment, and other supplies are mined, grown, produced, or manufactured, and from which the services are supplied.

5. Qualification of the Bidder

5.1 Bidders shall, as part of their bid:

a) Submit a written Power of Attorney (PoA) authorizing the signatory of the bid to commit the bidder;

i) In case of a General Power of Attorney, a true copy of the POA shall be duly notarized by Notary Public along with a declaration from the Company Secretary/Corporate Secretary endorsing the validity of the Power of Attorney.

ii) In case of a specific Power of Attorney (as per format included in forms & procedures), the original POA along with a copy of the resolution of Board of Directors for the specific appointment. In case of delegation by a General POA holder, the documents as sought under i) above shall be submitted along with the original specific POA.

b) Submit/include in their bids the following information/documents:

i) work commitments;

ii) availability of key personnel; and

iii) availability of major Contractor's Equipment

c) Each Bidder shall duly fill in the prescribed Data Sheets/ qualification particulars along with relevant experience certificates, Annual Reports and other information evidencing proof of their meeting the qualification criteria stipulated herein.

d) Submit an offer which is clear, comprehensive, unambiguous and complete in all respects including all necessary technical, contractual and commercial information.

e) Submit a Declaration, as per Proforma given in **Attachment-3 of Form-1, Letter of Tender appended under Section-5 of Volume 2** confirming that the bid submitted by the bidder is strictly in conformity with the documents issued by the Employer.

f) The payments against the Contract shall be made through Escrow account only.

5.2 Bids by Merged/Acquired/Subsidiary Company shall comply with the following minimum requirements:

a) Commitment by the Parent/Holding Company to sign a separate agreement with Employer (as per format contained in **Attachment-6 of Form–1, Letter of Tender appended under Section-5 of Volume 2** confirming full support for the technical and financial requirements of the subsidiary company and commit to take up the work itself in case of non-performance by the subsidiary company in the event of award of the work to the subsidiary company.

b) Parent/Holding Company shall submit an undertaking along with the bid as per format contained in **Attachment-6 of Form–1, Letter of Tender appended under Section-5 of Volume 2** that in case Bidding Company (Subsidiary Company) gets qualified and awarded the work package on the strength of Parent/Holding Company, Parent/Holding company shall furnish an additional performance bank guarantee of value equivalent to (5%) five percent of the Accepted Contract Amount or the portion of work (as the case



may be, in addition to normal Performance Bank Guarantee to be submitted by the Bidder to the Employer besides entering into a separate Agreement as per **(Form-9 or Form-10 appended under Section-5 of Volume 2)**, as applicable.

5.3 Bids submitted by a Bidder with Sub-contractor(s), shall comply with the following minimum requirements:

i) The Bidder and Sub-contractor(s) should submit separate undertakings (as per Form-10 appended under Section-5 of Volume 2) that the Bidder and Sub-contractor(s) shall be responsible for execution of that items of the work for which they claim to have specific experience.

ii) In order to ensure serious participation of the Sub-contractor(s) for work proposed to be executed by the Sub-contractor(s), a Joint Deed of Undertaking (as per Form-10 appended under Section-5 of Volume 2) shall be required to be submitted by the Bidder and Sub-contractor(s). Besides this, Sub-contractor(s)/Manufacturer(s) shall submit an additional Performance Bank Guarantee equivalent to 5% (five percent) of corresponding value of work sublet in addition to Performance Bank Guarantee for whole Contract submitted by the bidder on award of work.

5.4 The minimum qualifying requirement for the eligible bidders is as under:

a. Technical Criteria

i) General Experience

Experience as a prime Contractor having successfully completed at least one Electro-Mechanical work in a hydropower project on EPC/turnkey basis of Contract Value not less than **BTN/INR 6,000.00 million**, with minimum installed capacity of 400 MW in preceding twenty (20) years (start to finish) reckoned up to 28 days prior to bid submission deadline and which are in successful operation for at least two (2) years without any major operational issues reckoned from the taking over of the works.

To determine the value of work done by the Contractor during the last 20 years it shall be escalated at the rate of 5%, compounded annually.

ii) Specific Experience

Must have successfully carried out design, manufacturing, supply, erection and commissioning of the following Electro-Mechanical works in hydropower projects in preceding twenty (20) years (start to finish) reckoned up to 28 days prior to bid submission deadline and which are in successful operation for at least two (2) years without any major operational issues reckoned from the taking over of the works:

a) Vertical Pelton Turbine of minimum 100 MW unit capacity; and

b) Synchronous Generator of minimum 120 MVA unit capacity.

The bidder shall provide a notarized copy of the Completion Certificate indicating successful completion of the scope of works. In addition, corresponding to the Work Completion Certificate of at least one EM Works in Hydropower Projects under the General Experience, the bidder should also submit Performance Certificate issued by the Employer/Client that the EM components have been in successful operation without any major operational issues for last two years reckoned from the taking over of the Works.

b. Financial Experience

i) **Net-worth** of the Bidder for Financial Year immediately preceding the date of bid opening shall be equal to or more than **BTN/INR 2,300.00 Million**.

Net worth for this purpose shall be defined as:

= Paid up share capital
Add: Reserves net of losses
Subtract: Revaluation reserves
Subtract: Intangible Assets
Subtract: Miscellaneous expenditures to the extent not written off]

Net-worth of the Bidder shall be based on the audited accounts.

ii) **Average Annual Turnover** for the last 5 (Five) Financial Years immediately preceding the last date of Bid submission shall be equal to **BTN/INR 11,200.00 Million** only.

iii) The Bidder must have a minimum credit facility of **BTN/INR 3,600.00 Million** only, in any one of the following:

- BG Limits
- LC Limits
- Overdraft/Cash Credit Limits

c. Bid Capacity

The available bid capacity of the bidder as of 28 days prior to deadline for bid submission date, calculated as under, should not be less than the estimated cost of the contract package.

Available Bid Capacity = 2.0 x A x N - B

Where,

A = Maximum value of works executed in any one year during last five years (updated to the current price level i.e. 28 days prior to deadline for bid submission date by adding 5% per year, compounded annually) for construction works completed/under execution.

N = number of years prescribed for completion of the contract package under consideration/bidding.

B = value at current price level of existing commitments and ongoing works to be completed in the next 'N' year

Bidders to furnish details for ascertaining Bid Capacity under **APPLICATION FORM-5 under Section 2 of Volume 1** of the Bidding Document.

Notes for Technical Criteria:

1. *For both General Experience and Specific Work Experience requirements, during the past 20 years shall mean start to finish of the work in the preceding 20 years. The beginning and end date shall fall within the preceding 20 years reckoned 28 days prior to bid submission deadline.*
2. *For evaluation of specific experience of Bidder, following criteria shall be considered:*

   2.1 The evaluation of Bidder's specific experience for a work executed on JV basis shall be based on his role and scope of work in such joint ventures. To establish his role and scope of work in such joint venture contracts, the Bidder shall adduce documentary evidence to the extent of his claimed experience. In case the quantum of work as per experience certificate does not match with the scope of work as defined in the JV Agreement, the experience credentials shall be considered as per the experience certificate issued by the Employer/Client.

2.2 In case the specific work experience certificate has been issued in the individual name of the JV partner, the work executed by the Bidder shall be considered.

2.3 In case scope of work of individual partners is not clearly defined in the JV agreement, then credentials of Bidders being partner in a JV shall be decided in the following manner:

a) Where specific experience certificate in respect of individual JV partner is available, the same shall be considered to the extent of work executed by such JV partner.

b) Where specific experience certificate is not available, or experience certificate is issued in the name of JV, the evaluation shall be done in the following manner:

i) In case the participation/profit sharing percentage of Bidders as per JV agreement is at least 35%, full credit of the work executed by the JV shall be given to such Bidders.

ii) In case the participation/profit sharing percentage of Bidders in JV agreement is less than 35%, no credit of work executed under JV shall be given to such Bidders.

iii) Notwithstanding i) and ii) above, in case of availability of specific experience certificate, a) above shall apply.

2.4 In case both participations share and profit-sharing ratio are available in the JV Agreement, participation share shall prevail.

3. *The word **"successfully executed/completed/carried out"** means the bidder should have completed the specified parameter mentioned above even if the entire work of the contract is not completed.*
4. *The word **"major operational issues"** shall mean failure of the Generating Unit arising from defects in design and/or workmanship, which resulted in the Unit being in a continuous breakdown condition for a period of thirty (30) consecutive calendar days or more.*
5. *All qualifying works can be from the same project or different projects.*

Notes for Financial Criteria:

1. *The Net-worth shall be calculated based on subscribed and paid-up Share Capital plus Share Premium plus Free Reserve plus Unallocated balance/surplus amount of Profit & Loss Accounts less (a) Expenses not written off and (b) Accumulated Loss in Profit & Loss Accounts if not reduced from Reserve & Surplus. The revaluation reserves, capital reserves and amount of intangible assets like goodwill etc. will not be taken into account while calculating Net Worth.*
2. *Income other than related business shall not be considered for arriving at the Average Annual Turnover.*
3. *The Bidder's financial evaluation vis-a-vis the requirement as stipulated above shall be done on the basis of duly Audited Annual Report for the immediately preceding 5 (five) years submitted by the Bidder along with the Bid. Further, standalone audited Annual Financial Statement of the Bidder shall be forming part of the Annual Report.*
4. *In case where Audited financial results for the immediately preceding year are not available, then a statement of account as on the closing date of the immediately preceding financial year depicting the Turnover, working capital and Net Worth*

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(calculated as per laid down criteria) duly certified by their Statutory Auditor/ Certified Public Accountant carrying out the statutory audit shall be enclosed with the Bid along with copy of appointment letter of the Statutory Auditor.

5. *Wherever, the Annual Report duly notarized copies of Audited Annual Financial Statement are in language other than English, then copy duly translated in English language and certified by approved/ recognized English translator shall be submitted with the Bid.*
6. *In addition to above, wherever audited Annual Financial Statement contain turnover pertaining to other activities besides related business turnover of Bidder and breakup of related business turnover is not directly available from such financial statements, then statement of account depicting the related business turnover for that year duly certified by their Statutory Auditor shall also be enclosed with the Bid.*
7. *For the purpose of compliance to the stipulated turnover criteria given at Financial Criteria, the turnover from Joint Ventures(s) as declared in the Joint Venture Agreement shall also be considered.*
8. *The proportionate JV Turnover shall be certified by their statutory Auditor in the absence of the same not appearing separately/distinguished item in Audited Financial Statement.*
9. *The aggregate of cash flow as depicted from audited balance sheet shall be considered for the purpose of calculating Cash flow. Current assets and current liabilities will be considered as classified in the audited balance sheet for the year immediately preceding the date of opening of Bids. In case current assets and/or current liabilities are not classified separately in audited Balance Sheet, a certificate from Statutory Auditor/CPA carrying out the Statutory Audit, for current assets and/or current liabilities, as the case may be, clearly defining the items considered for the same, should be enclosed. However, trade payables shall be a part of current liabilities. The statement displaying Cash Credit limits shall not be more than three months old as on the last date for submission of Bids.*
10. *The banking reference/letter of comfort issued to the bidder by the bank for providing working capital shall not be accepted and considered.*
11. *Sub-contractor(s)/Manufacturer(s) turnover shall not be considered.*

5.5 The Bidder shall also submit detailed proposals outlining bidders proposed methodology of manufacturing and erection backed with their Equipment planning and deployment, duly supported with broad calculations and quality control procedures proposed to be adopted, demonstrating their capability of achieving the completion of Works as per specified Interim Contract Milestones within the stipulated Time for Completion referred to in Appendix to Tender.

5.6 Litigation History

The bidder shall furnish disclosure in respect of past history of litigation for a period of 5 years. The litigation history shall comprise the contracts which are completed and also under execution at present.

6. Nature of Bidders

6.1 The Bidder should be a single entity for participating in the tendering for this Project or with Sub-contractor. Bids from subsidiary Company shall also be considered.

Attachment-7 of Form-1, Letter of Tender appended under Volume 2.

6.2 Bids by Merged/ Acquired/ Subsidiary Companies

In case of a Bidder's company formed after merger and/ or acquisition of other companies, past experience and other antecedents of the merged/ acquired companies will be considered for qualification of such Bidders Company provided such Bidders Company continues to own the requisite assets and resources of the merged/acquired companies needed for execution and successful implementation of the work packages put to tender.

Similarly, if the Bidder's Company is a subsidiary company and applies for qualification on the unconditional technical and financial strength of the Parent/ holding company, the same shall be considered provided the Parent/Holding company commits to sign a separate agreement with the Employer evincing full support for the technical and financial requirements of the subsidiary company and commits to take up the work itself in case of non-performance by the subsidiary company in the event of award of the work to subsidiary company. An undertaking by the Parent/Holding Company to this effect shall be accompanied by Board resolution passed to this effect & submitted along with the bid (in the format provided in the Bid Document).

In case Bidding Company (subsidiary company) gets qualified and awarded the work package, the Parent company/holding Company will be required to furnish an additional performance bank guarantee of value equivalent to (5%) five percent of the Accepted Contract Amount or portion of work (where subsidiary Company is Joint Venture partner) as the case may be, in addition to normal Performance Bank Guarantee to be submitted by the Bidder to the Employer besides entering into a separate Agreement in the requisite Format provided in the Bid Document. However, for fulfillment of financial criteria, financial evaluation vis-à-vis the requirement as stated above shall be done on the basis of consolidated printed annual report for the immediately preceding 5 (five) years of the Parent/Apex Parent company submitted by the bidder along with the bid.

6.3 Bids with Sub-Contractor(s)

In case the Bidder does not have all requisite specific experience, he can associate Sub-contractor(s) for specified activities which he does not have the relevant experience.

The criteria to be met by such Bidders shall be as follows:

(i) The bidder himself to fully meet the following:
- General experience criteria specified in para 5.4, a, i);
- Specific experience criteria specified in para 5.4, a, ii);
- All criteria mentioned under Financial Experience in para 5.4, b.; and
- Bid Capacity as mentioned in para 5.4, c.

(ii) The Bidders and his Sub-contractor(s)/manufacturer(s) should submit separate undertakings that the Applicant/Sub-contractor(s)/manufacturer(s) shall be responsible for execution of that item of work for which they claim to have specific experience.

(iii) Sub-contractor other than Design Consultant shall submit Performance Bank Guarantee equivalent to 5% of value of Work sublet in addition to the Performance Bank Guarantee for whole contract submitted by the Bidders on award of Work.

7. Cost of Bidding

7.1 The bidder shall bear all costs associated with the preparation and submission of its bid, and the Employer will in no case be responsible or liable for those costs, regardless of the conduct or outcome of the bidding process.

8. Site Visit

8.1 The bidders in their own interest, should inspect and examine the site and its surroundings and satisfy themselves, before submitting their bid, in respect of the site conditions including but not restricted to the following which may influence or affect the Works or cost thereof under the Contract:

a. Site conditions including access to the Site, existing and required roads and other means of transport/ communication for use by them in connection with the Works;

b. Requirement and availability of land and other facilities, for their enabling works, colonies, stores and workshops, etc.;

c. Ground conditions including those bearing upon transportation, handling and storage of materials required for the work or obtained there from;

d. Source and extent of availability of suitable materials including water, etc. and labour (skilled and un-skilled), required for Works and laws and regulations governing their use and employment;

e. Geological, meteorological, topographical and other general features of the site and its surroundings as are pertaining to and needed for the performance of the Works;

f. The type of Contractor's Equipment and facilities needed, preliminary to, for and in the performance of the Works; and

g. All other information pertaining to and needed for the Works including information as to the risks, contingencies and other circumstances which may influence or affect the work or the cost thereof under this Contract.

h. Environmental & social aspects.

i. All applicable taxes, duties, royalty, cess, octroi etc.

8.2 The bidders should note that information, if any, in regard to the site and local conditions, in these Bid Documents is indicative only and has been given merely to assist the bidders and is not exhaustive.

8.3 The bidders should note and keep in mind that the Employer shall bear no responsibility for former's lack of acquaintance of the Site and other conditions or any information relating thereto. The consequences of the lack of any knowledge, as aforesaid, on the part of the bidders shall be at their risk and cost and no charges or claims whatsoever consequent upon the lack of any information, knowledge or understanding shall be entertained or payable by the Employer.

8.4 The bidder and any of its personnel will be granted permission by the Employer to enter upon its premises and lands for the purpose of such visit, but only upon the express condition that the bidder, its personnel will release and indemnify the Employer and its personnel from and against all liability in respect thereof, and will be responsible for death or personal injury, loss of or damage to property, and any other loss, damage, costs, and expenses incurred as a result of the inspection.

8.5 The bidders should note and bear in mind that the costs of visiting the Site shall be at the bidder's own expenses.

8.6 The site visit report shall form part of Attachment - 4, "Bidder's Appreciation of the Project" as per requirement of Sub-clause 13.2 of ITB.

B. Bid Documents

9. Content of Bid Documents

9.1 The Bid Documents are those stated below, and should be read in conjunction with any Addenda issued in accordance with Clause 11:

Volume – 1	Section – 1	Abridged Notice Inviting Tender and Notice Inviting Tender (NIT).
	Section – 2	Instructions to Bidders (ITB), Bid Data, Qualification Forms, Information for Bidders (IFB) and Construction Schedule.
Volume – 2	Section – 3	General Conditions of Contract (FIDIC) for Plant and Design-Build Contract for Electrical & Mechanical Plant and for Building & Engineering Works Designed by the Contractor **(FIDIC Yellow Book, 1st Edition 1999)**.
	Section - 4	Particular Conditions of Contract and Appendix to Tender
	Section - 5	Forms & Procedures - Form-1: Letter of Tender - Form-2: Form of Contract Agreement - Form-3: Bank Guarantee Form for Performance Security - Form-4: Bank Guarantee Form for Advance Payment - Form-5: Form of Taking Over Certificate - Form-6: Bank Guarantee Form for Release of Retention Money - Form-7: Hindrance Register - Form-8: Dispute Adjudication Agreement - Form-9: Parent/Holding Company Agreement - Form-10: Proforma for Joint Deed of Undertaking
Volume - 3		Price Schedules
Volume – 4	Section – 6 Section – 7 Section – 8	Employers' Requirements - General Technical Specification (GTS) - Particular Technical Specification (PTS) - Quality Assurance Plan (QAP)
Volume - 5		Tender Drawings
Volume - 6		Technical Data Sheets

10. Clarification of Bid Documents

10.1 A prospective Bidder requiring any clarification on the Bid Documents may notify the Employer in writing at the address indicated in the Bid Data Sheet under Clause 21.8(a). The Employer will respond to such requests by clarifying the same in the pre-bid meeting, which are received 5 days prior to pre-bid meeting. Any clarification requiring an amendment to the Bid Documents shall be issued as Addenda as per the Clause 11 [Amendment to Bid Documents]. The Employer shall not be obliged to respond to any request for clarification received later than the above period. Further, mere request for clarification from the Bidders shall not be a ground for seeking extension in the deadline for submission of bids. Employer's response (including an explanation of the query but not identification of its source) will be communicated in writing/e-mail to all the prospective bidders who have downloaded the Bidding Document. The prospective bidders shall promptly acknowledge receipt thereof in writing.

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11. Amendment to Bid Documents

11.1 At any time prior to the deadline for submission of Bids, the Employer may, for any reason, whether at its own initiative, or in response to a clarification requested by a prospective Bidder, amend the Bid Documents by issuing Addenda.

11.2 Any Addendum thus issued shall be part of the Bid Documents pursuant to Sub-Clause 9.1 and shall be communicated in writing/e-mail to all the purchasers of bid document. The prospective bidders shall promptly acknowledge receipt thereof in writing. The amendments to the Bid Documents will be binding on the bidders and it shall be construed that such amendment(s) to the Bid Documents have been taken into account by the Bidder in its bid.

11.3 To give prospective Bidders reasonable time in which to take an Addendum into account in preparing their Bids, the Employer shall extend as necessary the deadline for submission of Bids, in accordance with Clause 22 [Deadline for Submission of Bids].

C. Preparation of Bids

12. Language of Bid

12.1 The Bid, and all correspondence and documents related to the Bid exchanged by the bidder and the Employer shall be written in English. Supporting documents and printed literature furnished by the Bidder may be in another language provided they are accompanied with a certificate of the authorized translator certifying therein an accurate translation of the relevant passages in the above stated language, in which case, for the purposes of interpretation of the Bid, the translation shall prevail.

13. Documents Comprising the Bid

13.1 The Bid submitted by the Bidder shall comprise the following documents:

a. Letter of Tender duly completed and signed by the Bidder, together with all Attachments identified in Sub-Clause 13.2 below.
b. Data related to Qualifying requirements (including Qualification Forms and Data Sheets).
c. Price Schedule duly completed by the Bidder.

13.2 Each Bidder shall submit with Letter of Tender, the following attachments:

a. Attachment - 1: Bid Security

A bid security furnished in accordance with Clause 18.

b. Attachment - 2: Power of Attorney

A Power of Attorney, as per Sub-Clause 5.1 (a), indicating that the person(s) signing the Bid has the authority to sign the Bid and that the Bid is binding upon the Bidder during the full period of its validity in accordance with Clause 17.

c. Attachment - 3: Bidder's Eligibility and Qualifications

A declaration in respect of the submitted bid conforming to the requirement of Sub-Clause 5.1 (e).

d. Attachment - 4: Bidder's Appreciation of the Project

It should include a report on the site inspection, awareness and understanding of all the principal technical and logistic problems related to transportation and erection of the Contractor's Equipment and construction of Works. The site visit report shall form part of this Attachment.

e. Attachment - 5: Integrity Pact.

Integrity Pact Duly signed between Employer and the Bidder in accordance with Sub-Clause 3.3.

f. Attachment - 6: Undertaking by the Parent/Holding company

The commitment by the parent / holding company to sign a separate agreement with Employer for bids submitted by merged / acquired / subsidiary company and confirming full support for the technical and financial requirements of the subsidiary company (if applicable)

g. Attachment - 7: Undertaking by the Sub-contractor(s)

The commitment by the Sub-contractor to submit the Joint Deed of Undertaking in compliance to ITB Clause 5.4(ii) (if awarded the work).

h. Attachment - 8: List of approved Sub-contractors/Vendors and name of Sub-contractors/Vendors proposed by the Bidder (if applicable).

i. All other bidding documents issued by KHPL except Price Schedule not covered above shall be duly stamped and signed on each page by the authorized signatory(ies) to the bid.

 # (Any other Attachment, if required, shall be attached with letter of Tender)

14. Letter of Tender and Price Schedule

14.1 The Bidders shall complete the Letter of Tender and the appropriate Price Schedule furnished in the Bid Documents as indicated therein and in the Sub-section "Letter of Tender" and Price Schedules" of the Bid Documents, following the requirements of Clauses 15[Bid Price] and 16 [Currencies of Bid and Payment].

15. Bid Price

15.1 Unless stated otherwise in the Bid Documents, the Contract shall be for the whole Works as described in Sub-Clause 1.1, based on unit rates and prices quoted in the Price Schedules submitted by the bidders.

15.2 Bidders shall also include in their prices, cost of construction of infrastructural facilities not included in the Permanent Works and all temporary works as costs of performance and discharge of all obligations of the Bidders for the construction, execution and delivery of the works comprising the work packages.

15.3 The bidder shall fill in rates and prices for all items of the Works described in the Price Schedules. Items against which no rate or price is entered by the Bidder will not be paid for by the Employer when executed and shall be deemed covered by the rates for other items and prices in the Price Schedules. However, in case of major items not being quoted for, such bids shall be considered non-responsive and shall be liable for rejection, in which case the decision of Employer shall be final and binding.

15.4 All duties, taxes, royalty charges, outgoings and other levies applicable as on 28 days prior to bid due date shall be as described in Clauses 7.8 & 14.1 of the PCC and all such costs related to taxes, duties, royalty charges and outgoings etc. shall be deemed to be the responsibility of the selected bidder and shall not be paid for by the Employer.

15.5 Unless otherwise provided in the Bid Data and Particular Conditions, the rates and prices are subject to adjustment during the performance of the contract in accordance with the relevant provisions of contract.

15.6 The Bidders may offer discount/rebate on percentage basis in "Letter of Tender" which shall be applied uniformly to all unit rates and lump sum amount of the Price Schedules. Any discount/rebate not offered in the form and manner prescribed here-in-above shall not be considered by the Employer for the purpose of evaluation.

15.7 The trade terms used in the Bidding Documents shall be governed by the rules prescribed in the current edition of incoterms, published by the International Chamber of Commerce.

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16. Currencies of Bid and Payment

The currency(ies) of the bid shall be, as specified in the BDS. The unit rate and the price of each item given in the Price Schedules shall be quoted by Bidder, as stated in the Bid Data Sheet. The payment shall be made by the Employer in the currency(ies) as specified in BDS.

17. Bid Validity

17.1 Bids shall remain valid for the period stipulated in the Bid Data from the Bid submission deadline.

17.2 In exceptional circumstances, prior to expiry of the original bid validity period, the Employer may request the bidders to extend the period of bid validity for a specified additional period. The request and the responses thereto shall be made in writing or by e-mail. A bidder may refuse the request without forfeiting its bid security. A bidder agreeing to the request will not be permitted to modify its bid, but will be required to extend the validity of its bid security for the period of the extension, and in compliance with Clause 18 [Bid Security] in all respects.

18. Bid Security

18.1 The bidder shall furnish, as part of its bid, a bid security for the amount and currency stipulated in the Bid Data.

18.2 The bid security shall be in the following manner:

a. An irrevocable unconditional bank guarantee issued by a bank/financial institution in Bhutan or any nationalized/scheduled bank in India with endorsement/counter guarantee by a bank/financial institution in Bhutan.

b. Bank Guarantees for the Bid Security shall be valid for a period of not less than 210 (two hundred and ten days from the Bid Submission deadline specified in Clause 25 [Bid Opening]. The Bid Security shall be made payable without any condition/demur 'on demand' to the Employer.

c. The format of the bank guarantee shall be in accordance with the form of bid security included in Attachment -1, Volume -2, Section - 5.

18.3 Any Bid not accompanied by an acceptable Bid Security and Letter of Tender together with its attachments shall be rejected by the Employer as non-responsive.

18.4 Save as provided in Clause below, the Bid Security of the unsuccessful Bidders will be discharged / returned as promptly as possible, but not later than 90 (ninety) days after the expiration of the Bid Validity Period or award of the Works whichever is earlier. No interest shall be payable on the amount of security.

18.5 The Bid Security of the successful Bidder will be returned when the Bidder has signed the Agreement and furnished the required performance security.

18.6 The Bid Security shall be forfeited if:

a. the Bidder withdraws its Bid or varies any terms & conditions in regard thereto during period of bid validity or;

b. in the case of a successful Bidder, if he fails within the specified time limit to;

i. sign the Agreement, or

ii. furnish the required performance security.

c. the Bidder adopts corrupt or collusive or coercive or fraudulent practices covered under ITB Clause-35 [Corrupt or Fraudulent Practices] or defaults committed under Integrity pact.

d. the Bidder does not accept the corrections of errors.

19. Pre-Bid Meeting

19.1 The Bidder is invited to attend a Pre-Bid meeting, which will take place at the venue and time stipulated in the Bid Data. Non-attendance at the pre-bid meeting will not be a cause for the disqualification of a bidder.

19.2 The purpose of the meeting will be to clarify issues and to answer questions on any matter that may be raised at that stage.

19.3 The Bidder is requested to submit any questions in writing/e-mail not later than 7 days before the pre-bid meeting which will be responded to and clarified in the Pre-Bid meeting.

19.4 Any modifications of the Bid Documents listed in Sub-Clause 9.1 which may become necessary as a result of the pre-bid meeting shall be made by the Employer exclusively through the issue of an Addendum pursuant to Clause 11[Amendment to Bid Documents].

20. Format and Signing of Bid

20.1 The Bidder shall prepare the documents comprising the Bid as described in Clause 13[Documents Comprising the Bid] of these Instructions to Bidders.

20.2 The Bid shall be signed by a person duly authorized to sign on behalf of the Bidder, pursuant to Sub-Clause 5.1(a) or 5.2(b), as the case may be.

20.3 The Bid shall contain no overwriting, alterations, omissions, or additions, unless such corrections are initialed by the person or persons signing the Bid. Corrections if any shall only be made by scoring out the cancelled portion, writing the correction, initialing and dating it by the person or persons signing the Bid.

20.4 The Bids shall be signed as under:

a. If the Bid is submitted by an individual, it shall be signed by the proprietor above his full name and name of the firm with its current business address.

b. If the Bid is submitted by a proprietary firm, it shall be signed by the proprietor.

c. If the Bid is submitted by a firm in partnership, it shall be signed by a partner holding the power of attorney. A certified copy of the partnership deed duly registered and current business address of all the partners of the firm shall also accompany the Bid.

d. If the Bid is submitted by a limited company, it shall be signed by a duly authorized person holding the power of attorney together with a Board resolution in this regard for signing the Bid, in which case a certified copy of the power of attorney supported with resolution of Board of Directors shall accompany the Bid. Such limited company may be required to furnish satisfactory evidence of its existence before the contract is awarded.

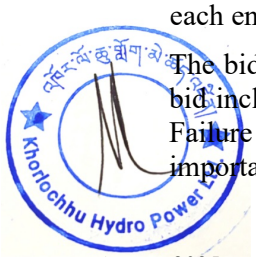
e. All witnesses and sureties shall be persons of status and their full names, occupations and addresses shall be stated below their signatures.

D. Submission of Bids

21. Preparation and Submission of Bids

21.1 Bids shall be submitted in single stage with contents indicated in paragraphs 21.2 and 21.3 below. The Bids shall be submitted in one original and two copies marked as ‘Original’, ‘Copy 1’ and ‘Copy 2’, as per the submission schedule laid by the Employer. The Bid shall be submitted in separately sealed envelopes duly marked Envelope I and Envelope II and each envelope shall contain documents as stated below.

The bid should be serially numbered and properly indexed mentioning all constituents of bid including any enclosures/attachments etc. and their location page numbers in the bid. Failure to submit the bid in systematic manner as above may result oversight of any important information provided by the bidder for which Employer shall not be responsible.



The Techno-commercial bid of only those bidders who meet the qualifying criteria shall be evaluated. After Techno-commercial evaluation, the Price Schedules of Bidders whose Techno-commercial proposals are found responsive shall be opened.

21.2 Bidders shall submit the following documents in separate sealed envelopes by the due date and time of receipt of bid as mentioned in Bid Data. The envelope received late or after the prescribed due date and time will not be entertained. Employer will not be responsible for any postal delay.

Envelope-I: Technical Bid (Qualification Particulars and Techno-commercial Unpriced Bid) shall contain the following:

i. The Letter of Tender (including all attachments) duly filled in and signed without indicating the prices.
ii. Data related to Qualifying requirements (including Qualification Forms and Data Sheets).
iii. All information and other data required to be submitted by Bidders in accordance with the Instructions to Bidders and the Addenda, including all supporting documentation, which the Bidder wishes to submit as part of his Techno-commercial Bid.

All bidding forms and data sheets relating to prices or having other financial implications shall be left blank, which must also contain no other information, data and details relating to prices. The above documents shall be duly signed by the Bidder.

The documents specified under ITB Clause 9.1, which are not submitted with the bid, will be deemed to be part of the bid and the bidder by submitting its bid shall be deemed to have accepted them unconditionally. The bidder shall treat the bidding documents and contents thereof as confidential.

21.3 **Envelope-II: Financial Bid** (Price Bid) shall contain the following:

a. The Letter of Tender, complete in all respects and duly signed.
b. The Price Schedules duly filled in conformity with the tender specifications.
c. All other material required as per the Instructions to Bidders or Addenda to be included in the Price Bid.

No material relating to any technical matters shall be included in the Price Bid.

21.4 All instructions in this respect contained in Section-2 (Instructions to Bidders) and Addenda, if any, shall be followed.

21.5 **Marking of Submission:** Envelope I shall be super scribed on top as “TECHNCIAL BID KEM-I” and Envelope II shall be super scribed on top as “FINANCIAL BID – KEM-1”.

21.6 The Bidder has the option of sending the Bid by registered post/courier or by submitting the Bid in person, so as to reach by the date and time indicated in the Bid Data under clause 22 [Deadline for Submission of Bids]. Bids submitted electronically shall not be accepted. The Bidder shall be responsible for timely delivery of Bids and Bids received after the stipulated date and time shall not be accepted.

21.7 No price sensitive information is to be submitted in Envelope-I.

21.8 The inner and outer envelopes shall;

a. be address to the Employer at the address provided in the Bid Data;
b. bear the name and identification number of the contract as defined in the Bid Data; and
c. provide a warning not to open before the time and date for bid opening, as specified in the Bid Data.



21.9 In addition to the identification required in sub-clause 21.7, the envelope shall indicate the name and address of the Bidder to enable the bid to be returned unopened in case it is declared "late" pursuant to Clause 22 [Deadline for Submission of Bids] and to identify pursuant to Clause 24 [Modification, Substitution and Withdrawal of Bids].

21.10 If the envelopes are not sealed and marked as above, the Employer will assume no responsibility for the misplacement

22. Deadline for Submission of Bids

22.1 Complete Bids must be received by the Employer at the address as specified in Sub-Clause 21.8 not later than the time and date stipulated in the Bid Data. In the event of the specified date for the submission of bids being declared a holiday for the Employer, the bids will be received up to the specified time on the next working day.

22.2 The Employer may, in exceptional circumstances and at its discretion, extend the deadline for submission of bids by issuing an Addendum in accordance with Clause 11[Amendment to Bid Documents], in which case all rights and obligations of the Employer and the bidders previously subject to the original deadline will thereafter be subject to the deadline as extended.

23. Late Bids

23.1 Bids, if received by the Employer after the deadline for submission of Bids prescribed in Bid Data, will be considered as "Late Bid" and shall be returned unopened.

24. Modification, Substitution and Withdrawal of Bids

24.1 The Bidders may modify, substitute, or withdraw his bid after its submission but in any case, before the official deadline for submission mentioned in Bid Data under clause 22 [Deadline for Submission of Bids] by giving modification or substitution or withdrawal notice in writing to the Employer. The Bidder's modification or substitution or withdrawal notice shall be prepared, sealed and clearly marked as "MODIFICATION" or "SUBSTITUTION" or "WITHDRAWAL" as appropriate and delivered prior to the Bid Due Date and Time.

24.2 Any alteration/ Modification in the Bid or additional information supplied subsequently to the Bid Due date and Time, shall be disregarded.

24.3 Withdrawal of a Price Bid during the interval between the deadline for submission of Bids and expiration of the period of Bid validity specified in Clause 17 [Bid Validity] shall result in the forfeiture of the Bid Security pursuant to Sub-Clause 18.6 hereby.

E. Bid Opening and Evaluation

25. Bid Opening

25.1 The Employer will open the Bids in the presence of Bidder's designated representatives (authorization letter to be submitted) who choose to attend, at the time, date, and location stipulated in the Bid Data.

The Bidders' representatives who are present shall sign a register evidencing their attendance. No Bid shall be rejected at the Bid opening except for the conditions stipulated under Clause 23 [LATE BIDS] and Sub-Clause 5.2.d. hereof.

Envelopes marked "WITHDRAWAL" and/or "MODIFICATION" and/or "SUBSTITUTION" shall be opened and read out first. Bids for which an acceptable notice of withdrawal has been submitted pursuant to Clause 24 of the ITB shall not be opened. Unopened bids shall immediately be returned to the respective Bidder.

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The date of opening of Price Bids shall be intimated separately to all the Bidders meeting the specified qualifying criteria and also whose techno-commercial bids are found responsive. Price Bids shall be opened on due time, date and place as specified in invitation letter by the Employer. Price Bids of the Bidders not meeting specified qualifying criteria and/or whose techno-commercial bids are not found responsive shall not be considered for opening and shall be returned unopened to the bidder.

25.2 At the time of opening, all important information and any such other details as the Employer may consider appropriate, will be announced by the Employer. This shall include but may not be limited to the Bidders' names, the Bid Prices including deviation, any discounts and the presence (or absence) of bids security.

25.3 The Employer will open the Bids in the presence of Bidders' designated representatives (authorization letter to be submitted) who choose to attend, at the time, date, and location stipulated in the Bid.

26. Process to be Confidential

26.1 Information relating to the examination, clarification, evaluation and comparison of bids, and recommendations for the award of a contract shall not be disclosed to bidders or any other persons not officially concerned with such process until the award to the successful bidder has been announced. Any effort by a bidder to influence the Employer's processing of Bids or award decisions may result in the rejection of the bidder's bid.

27. Clarification of Bids

27.1 To assist in the examination, evaluation, and comparison of bids, the Employer may, at its discretion, ask any bidder for clarification of its Bid, including breakdown of unit rates as per the format given in Data Sheet – 10, Volume - 6, Section 9. The request for clarification and the response shall be in writing but no change in the price or substance of the bid shall be sought, offered, or permitted except as required to confirm the correction of arithmetical errors discovered by the Employer in the evaluation of the Bids in accordance with Clause 28 [Examination of Bids and Determination of Responsiveness] hereof.

28. Examination of Bids and Determination of Responsiveness

28.1 The basis and methodology for evaluation of the Qualification Particulars and techno-commercial bids shall generally be as described in the supplement to Instructions to Bidders attached as ANNEXURE - A to this ITB. The Employer will examine the bids to determine whether they are complete, whether any computational errors have been made, whether required securities and cost of Bid Document have been furnished, whether the documents have been properly signed, whether all the requisite declaration, undertakings have been furnished and whether the bids are generally in order

28.2 Arithmetical errors will be corrected at the time of evaluation of Price Bid and the corrected figure will be considered for the purpose of evaluating Bid price. The corrections in the Bid price shall be done as per the provisions of this clause and shall be binding on the Bidder. If the Bidder does not accept the correction of errors as per the provisions of this clause, the Bid will be rejected and the Bid security will be forfeited.

i. If there is a discrepancy between the product of unit price & quantity for any item and the total price for such item, the product of unit price and quantity, will prevail and the total price shall be corrected.

ii. If there is discrepancy between summation of subtotals and total price, the summation of subtotal price shall prevail, and the total price shall be corrected.

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iii. If there is a discrepancy between words and figure, wherever the Bid document requires the figures to be written in both words and figures, the amount in word will prevail unless the amount expressed in figures has an arithmetic error.

iv. In case the Bidder has not filled up unit price as well as amount against any item, Employer shall treat the price of unfilled items as zero for the purpose of evaluation & comparison and award, with the assumption that the cost have been absorbed elsewhere in the Price Bid unless the item, in view of Employer, is declared as major item pursuant to Sub-Clause 15.3.

v. In case prices for some items are given by a Bidder as lump sum where unit rates are required, Employer reserves the right to arrive at unit rate on the basis of dividing the entered lump sum amount by the specified quantity.

28.3 The Employer may waive any minor informality, non-conformity or irregularity in a bid that does not constitute a material deviation and that does not prejudice or affect the relative ranking of any Bidder as a result of the evaluation of Bids, pursuant to these Clauses. In case a Bidder chooses to offer a discount/rebate, then he may do so by offering it on a percentage basis in 'Letter of Tender' which shall be applied uniformly to all the unit rates and lump sum amount of the Price Schedules. Any discount/rebate not offered in the form and manner prescribed here-in-above shall not be considered by the Employer for the purpose of evaluation.

28.4 Prior to the detailed evaluation, the Employer will determine whether each Bid is of acceptable quality, is complete and is substantially responsive to the Bid documents. For purposes of this determination, a substantially responsive Bid is one that conforms to all the terms, conditions and specifications of the Bid documents without material deviations, objections, conditionality or reservations. A material deviation, objection, conditionality or reservation is one (i) that affects in any substantial way the scope, quality or performance of the Contract; (ii) that limits in any substantial way, inconsistent with the Bid documents, the Employer's rights or the successful Bidder's obligations under the Contract; or (iii) whose rectification would unfairly affect the competitive position of other Bidders who are presenting substantially responsive bids.

The Employer's determination of a Bid's responsiveness is to be based on the content of the Bid itself without recourse to extrinsic evidence.

28.5 If a Bid is not substantially responsive, it will be rejected by the Employer, and shall not subsequently be made responsive by correction or withdrawal of the nonconforming deviation or reservation.

28.6 All the bidders shall be informed, about their status of qualification/disqualification/techno-commercial responsiveness, in a single letter.

29. Evaluation and Comparison of Bids

29.1 In evaluating the Price Bids, the Employer will determine for each Bid the Evaluated Bid Price by adjusting the Bid Price as follows:

a) making any correction for errors pursuant to Sub-Clause 28.2;

b) taking into account discount offered (if any) pursuant to Sub-Clause 28.3.

29.2 The effect of the price adjustment provisions of the Conditions of Contract, applied over the period of execution of the contract, shall not be taken into account in bid evaluation.

29.3 Any adjustments in price that result from the above procedures shall be carried out, for purposes of comparative evaluation, to arrive at an "Evaluated Bid Price."

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29.4 If the Bid, which results in the lowest Evaluated Bid Price, is front loaded in relation to the Employer's estimate of the items of work to be performed at early stage under the Contract, the Bidder may require to furnish additional performance security as determined by the Employer, to cover front loading and valid up to 90 days beyond defects liability period, set forth in Clause 34 [Performance Security] hereof at the expense of the bidder to protect the Employer against financial loss in the event of default of the successful Bidder under the Contract.

29.5 **Bid for 2 (two) or 3 (three) Bearing Arrangement**: Bidders may submit bids offering either 2 (two) or 3 (three) bearing arrangement Vertical Pelton Turbine Generator, or both. For the purpose of technical bid evaluation, both arrangements shall be considered as an equivalent bid.

If Bidder submits bids for both arrangements or only one arrangement, the Employer will evaluate the financial bid based on the evaluation criteria set out in the bidding document.

During financial bid evaluation, cost loading shall be done either on 2 (two) bearing or 3 (three) bearing arrangement proposal as deemed appropriate and suitable by the Employer. In addition, during contract award the Employer also reserves its right to select either arrangement.

29.6 **Cost Loading of Financial Bids**

29.6.1 **Weighted Average Efficiency Differences:** During bid evaluation , the differences in efficiencies of various Bids shall be considered and loading for equalization shall be done if the combined weighted average efficiency of Turbine and Generator is found less than the highest offered guaranteed weighted average efficiency.

The combined weighted average efficiency of Turbine and Generator is calculated by the following formula: -

$$(\eta_{wAve.}) = 0.18 \times \eta_{110} + 0.31 \times \eta_{100} + 0.26 \times \eta_{75} + 0.25 \times \eta_{50}$$

Where,

- $\eta_{wAve.}$ = Combined weighted average efficiency
- η_{110}, η_{100}, η_{75}, & η_{50} are efficiencies at 110%, 100%, 75% & 50% of rated output of 150 MW at generator terminals respectively operating at rated head.

Combined efficiencies of Unit at 110%, 100%, 75% & 50% of rated output of 150 MW shall be the product of turbine efficiency and generator efficiency at corresponding percentage of rated output. The weighted average efficiencies shall be guaranteed. Bidder with the maximum combined weighted average efficiency shall be considered as the base and other bidders shall be cost loaded for the difference in the combined weighted average efficiency. The cost loading will be done as follows:

For every one hundredth of percent (0.01%) of combined weighted average efficiency guaranteed by the bidder.	Cost Loading of BTN/INR 13.090 million

The preferred minimum combined weighted average efficiency is 90.16%.

29.6.2 **Cost loading for Loss on Generator Transformers and ICTs:** During bid evaluation, for differences in losses of various Bids, the cost loading for equalization shall be done if the losses of Generator Transformer and ICT are found higher than the lowest offered losses. The cost loading will be done as follows:

For every kW of losses for each Unit	Cost Loading of BTN/INR 0.220 million

F. Award of Contract

30. Award

30.1 Subject to Clause 32 [Notification of Award] hereunder, the Employer will award the contract to the Bidder, meeting the specified qualifying requirement and also whose Bid has been determined to be substantially responsive to the Bid Documents and who has offered the lowest Evaluated Bid Price pursuant to Clause 29, provided that such Bidder has been determined to be eligible in accordance with the provisions of Clause 3 [Eligible Bidders] and 5 [Qualification of the Bidder] of ITB hereof.

31. Employer's right to accept any Bid and to reject any or all Bids

31.1 The Employer reserves the right to accept or reject any Bid, or cancel/ withdraw invitation to Bid for any reason including national defense and security considerations, and annul the bidding process and reject all Bids at any time prior to award of contract, without thereby incurring any liability to the affected Bidder(s).

32. Notification of Award

32.1 Prior to expiration of the period of Bid validity prescribed by the Employer, the Employer will notify the successful Bidder by electronically and confirmed by registered letter or courier that its Bid has been accepted. This letter (hereinafter and in the Conditions of the Contract) shall be called the "Letter of Acceptance" as prescribed in the Bid document.

32.2 The notification of award (letter of Acceptance) will constitute the formation of the contract until the contract has been effected pursuant to Clause 33 [Signing of Agreement] hereunder.

32.3 The unsuccessful bidders shall be informed simultaneously about status of their Bids,

33. Signing of Agreement

33.1 After notifying the successful Bidder that its Bid has been accepted, the Employer will prepare the Agreement in the form provided in the Bid Documents, incorporating all agreements between the parties. The contract shall be signed in two originals (one for Employer and one for Contractor). The Contractor shall provide to the Employer 25 sets of the Contract for its execution, free of charges.

33.2 After issue of Letter of Acceptance, the Employer shall notify the Contractor about the readiness of the Agreement. The Employer and the successful Bidder shall sign the Agreement within 28 days from the date of issue of Letter of Acceptance to the Contractor.

33.3 Upon issue of Letter of Acceptance as per Clause 32 [Notification of Award] hereof, the Employer will notify the other Bidders that their Bids have been unsuccessful and their Bid Security will be returned.

34. Performance Security

34.1 Within 28 days from the date of issue of Letter of Acceptance, the successful bidder shall furnish to the Employer a Performance Bank Guarantee in the form stipulated in the Conditions of Contract and additional Performance Security (if required by the Employer) as per Clause ITB 29.4 above.



34.2 In case Bidding Company (subsidiary company) gets qualified and awarded the work package, the Parent company/Holding company, within 28 days from the date of issue of Letter of Acceptance, will be required to furnish an additional performance bank guarantee, as per Clause 4.2 of Particular Conditions Part B-Special Provisions, of value equivalent to five percent (5%) of the Accepted Contract Amount or portion of work (where subsidiary Company is a Partner) as the case may be, in addition to normal Performance Bank Guarantee to be submitted by the Bidder to the Employer besides entering into a separate agreement in the requisite Format provided in the Bid Document.

34.3 The bidders who are qualified on the strength of their Sub-contractor shall be required to furnish an additional Performance Bank Guarantee from their Sub-contractor as per Clause 4.2 of Particular Conditions Part B-Special Provisions.

34.4 The form of Performance Bank Guarantee provided in Volume-2, Section 5, of the Bid Documents may be used.

34.5 Failure of the successful bidder to comply with the requirements of Clause 33 [Signing of Agreement] or Clause 34 hereof shall constitute a breach of contract, cause for annulment of the award, forfeiture of the Bid Security, and any such other remedy the Employer may take under the provisions of the Contract .

35. Corrupt or Fraudulent Practices

35.1 It is expected from the Bidders that they will observe the highest standard of ethics during the bidding process and execution of such Contracts in pursuance of this policy:

a. For the purpose of this provision, the terms set-forth below shall mean as under:

(i) "corrupt practice" means the offering, giving, receiving or soliciting of anything of value to influence the action of a public official in the procurement process or in Contract execution.

(ii) "fraudulent practice" means a misrepresentation or omission of facts in order to influence a procurement process or the execution of a Contract.

(iii) "collusive practice" means a scheme or arrangement between two or more bidders, with or without the knowledge of Client, designed to establish bid prices at artificial, non-competitive levels.

(iv) "coercive practice" means harming or threatening to harm, directly or indirectly, person or their property to influence or affect the execution of Contract.

(v) "Integrity Pact" means an agreement signed between the Contractor and the Employer committing the persons/officials of both the parties, not to exercise any corrupt influence on any aspect of the Tender/Contract.

b. An agreement called Integrity Pact between the prospective Bidders and the Employer shall be signed committing the persons/officials of both the parties, not to exercise any corrupt influence on any aspect of the Tender/Contract.

c. A Bid shall be rejected by the Employer if it is determined at any stage that respective Bidder has engaged in corrupt or fraudulent or collusive or coercive practices or defaulted commitments under Integrity Pact in competing for or in executing the Contract in question and his Bid Security shall be forfeited. The Contractor shall not be entitled for any compensation whatsoever under this clause.

d. The Employer may declare a bidder ineligible, either indefinitely or for a stated period of time, to be awarded a Contract if it at any time determines that the bidder has engaged in corrupt or fraudulent or collusive or coercive practices in competing for, or in executing a Contract.

e. The documents/information submitted by Contractor may be verified by the officials of the Employer for its authenticity at any time and the Contractor shall provide all

facilities/co-operation in this regard. If it is found that any of the documents/ information submitted by the Contractor is not genuine, the Employer shall have full rights to cancel his Bid, forfeit the bid security and terminate the Contract, if awarded.



ANNEXURE-A: TECHNICAL EVALUATION

(ITB Clause 28.1)

1. Technical Evaluation shall be carried out on the basis of the technical submission by the Bidder, which will include the information and data provided by Bidders as specified in the Bid/Technical Data Sheets:

   - Work Commitment (Data Sheet 1)
   - Personnel Capabilities; Personnel Candidate data (Data Sheet 2 and 2A).
   - Contractor's Equipment Data (Data Sheet 3, 3A, 3B & 3C).
   - Quality Control Procedures (Data Sheet 4)
   - Proposed Site Organization, (Data Sheet 5).
   - Construction Programme (Data Sheet 6)
   - Construction Methodology (Data Sheet 7)
   - Bidder's Appreciation of the Project (Attachment 5 to Letter of Tender).

   The Bidders appreciation of the project should include a report on the site inspection carried out prior to submission of bid and must demonstrate full awareness and understanding of all the principal technical and logistic problems related to transportation and erection of the Contractor's Equipment, Materials, availability of Land and Infrastructures, Local Taxes/ duties/ royalties/levies/cess & applicable Laws for supply/erection works and other services.

2. To facilitate completion of the technical evaluation in the limited time available, Bidders are advised.

   a) To submit their technical documentation and all other data in the form and order indicated in the data sheets and/or as instructed above, and to ensure that all specific points on which information has to be submitted, as detailed in the Instructions to Bidders and any addenda thereto, are fully covered.

   b) To ensure that the documentation submitted is complete in all respects but also concise.

   As the Programme for Bid evaluation is short, the Employer cannot accept any obligation to request clarifications or substantiating information after bids have been submitted.

3. Even though the bidders meet the qualifying criteria as per clause No. 5 (ITB), they are subject to be disqualified if they have:

   a) made misleading or false representations in the forms, statements, declarations and attachments submitted in proof of the qualification requirements; and/or

   b) record of poor performance such as abandoning the works, not properly completing the contract, inordinate delays in completion, or financial failures etc.

   c) participated in the previous bidding for the same work and had quoted abnormally high or low bid prices and could not furnish rational justification for it to the Employer.

BID DATA SHEET

The following specific data for the Works to be procured shall complement, amend, or supplement the provisions in the Instructions to Bidders (ITB). Whenever there is a conflict, the provisions herein shall prevail over those in Instructions to Bidders.

Instructions to Bidders (ITB) Clause Reference	
1.1	**Summary of Works:** Design, manufacturing, supply, installation, testing and commissioning of Electro-Mechanical Works of 4x150MW Khorlochhu Hydropower Project located in Trashiyangtse District, Bhutan.
1.1	**Name and Address of the Employer:** Khorlochhu Hydro Power Limited, Corporate Office, Postal Box No. 46002, Doksum New Township, Trashiyangtse, Bhutan. Website: www.khpl.bt
1.2	**Period of Completion:** 42 Months
16.	The currencies of the Bid shall be combination of Bhutanese Ngultrum (BTN) or Indian Rupees (INR) and Euro (EUR) as detailed below: a) Bidders will quote in BTN/INR for components supplied from India or Bhutan. b) Bidders will quote in foreign currency EUR for components supplied from countries other than India or Bhutan. c) Bidders will quote in BTN/INR for services. Payment shall be made in the currencies as quoted in the Price Schedule.
17.1	**Period of Bid Validity**: 180 days
18.1	**Amount of Bid Security**: BTN/INR 180.00 Million
19.1	**Venue, Date and Time of Pre-Bid Meeting:** **Venue**: Corporate Office, Khorlochhu Hydro Power Limited, Doksum New Township, Trashiyangtse, Bhutan. **Date and Time**: September 09 - 11, 2025 at 10.00 AM (BST).
21.8 (a)	**Employer's address for the purpose of Bid Submission**: General Manager, Contracts & Procurement Division, Khorlochhu Hydro Power Limited, Corporate Office, Postal Box No. 46002, Doksum New Township, Trashiyangtse, Bhutan Email: gm.cnp@khpl.bt
21.8 (b)	**Contract Reference No.**: KHPL/C&PD/TENDER:KEM-1/2025/11534 dated 07.08.2025
22.1	**Deadline for Submission of Bids:** **Time and Date**: October 17, 2025 up to 10:30 AM (BST).

Instructions to Bidders (ITB) Clause Reference	
25.1	**Venue, Date and Time of Bid Opening:** **Venue:** Corporate Office, KHPL, Doksum New Township, Trashiyangtse, Bhutan. **Date and Time:** Envelope - I: October 17, 2025 at 11.00 AM (BST). Envelope - II: to be intimated later to the technically qualified bidder(s) meeting the specified qualifying criteria and also whose Technical Bids are determined/found responsive.

SECTION-2

QUALIFICATION FORMS

(Refer ITB Sub-Clause 13.1 b)



APPLICATION FORM – 1

General Information

1.	**Name of firm**	In case of Consortium/Sub-contractor ( ) Lead Partner ( ) Partner ( )Sub-contractor			
2.	**Head office address**				
		Country:			
3.	**Telephone** **Fax** **Email**	**Contact Person(s)** **Name** **Title/Position**			
4.	**Place of incorporation / registration Date**				
5.	**Legal status of firm**	**Field of specialty in business**			
6.	**Nationality of majority of owners or share-holders**	**Number of management executives** **Persons**			
7.	**Number of present permanent employee:**				**(unit: persons)**
		Name of Country	**Electrial Engineers**	**Other Engineer**	**Non-Engineering**
	Name of Country				
	Overseas branch 1				
	Overseas branch 2				
	All other branches				
8.	**Quality assurance system in head office**	**Certified by:**			

Date: _____ **Signature:** _____

APPLICATION FORM – 2

Financial Data

Name of the Company:*(Sole Bidder ~~or Partner Consortium and/or Sub-contractor(s))~~*

Bidder must fill this form.

Description	FY 1	FY 2	FY 3	FY 4	FY 5
Turnover from EM Works (in BTN/INR)					
Total Assets (TA)					
Total Liabilities (TL)					
Net Worth (NW):					
a. Subscribed and Paid-up share Capital					
b. Share Premium					
c. Free Reserves					
d. Unallocated balance/surplus amount of profit and loss accounts					
e. Expenses not written off					
f. Accumulated loss in profit and loss accounts if not reduced from reserves and surplus					
Total Net worth (a+b+c+d-e-f)					
Current Assets – Current Liabilities					

Fiscal Year (FY) begins from -------- in each calendar year.

Date _____ **Signature** _____

NB: *The Bidder's shall submit Audited Annual Report for the immediately preceding 5 (five) years in support of aforesaid financial details.*

APPLICATION FORM – 3

General Experience

Name of the Company: *(Sole Bidder or Partner and/or Sub-contractor(s)*

Experience as a prime Contractor having successfully completed at least one Electro-Mechanical work in a hydropower project on EPC/turnkey basis of Contract Value not less than BTN/INR **6,000.00 million** only, with a minimum installed capacity of 400 MW in preceding twenty (20) years (start to finish) reckoned up to 28 days prior to bid submission deadline, and in successful operation for at least two (2) years without any major operational issues reckoned from taking over of the works.

To determine the value of work done by the Contractor during the last 20 years it shall be escalated at the rate of 5%, compounded annually.

Sr. No.	Name of Project	Country	Applicant's own works done	Role of the Applicant (Prime Contractor)	Contract period m/yr to m/yr	Bidder's Contract Price (BTN/INR)
1						
2						
3						
4						
5						

Date _____ **Signature** _____

NB:

i) To please attach detailed data sheet wherever possible.

ii) Bidder to attach certificates in support of declarations made here-in-above.



APPLICATION FORM - 4

Specific Experience

Name of the Company: *(Sole Bidder or Partner of a Joint Venture and/or Sub-Contractor(s))*

Bidder is required to list contracts which have been successfully executed/completed/carried out up to the specified parameter mentioned here-in-below:

Name of Project	**Country of Execution**	**Name of Contract**	**Contractor's Role & Share** ***(Sole/Partner of JV or Sub-Contractor)***	**Schedule Completion/ actual Completion (month/year)**	**Details of Works executed w.r.t. Qualifying criteria**
Must have successfully carried out design, manufacturing, supply, erection and commissioning of the following Electro-Mechanical works in hydropower projects in preceding twenty (20) years (start to finish) reckoned up to 28 days prior to bid submission deadline and which are in successful operation for at least two (2) years without any major operational issues reckoned from the taking over of the works.: a) Vertical Pelton Turbine of minimum 100 MW unit capacity; and					
b) Synchronous Generator of minimum 120 MVA unit capacity					

Date_____ **Signature**_____

NB: *To please attach detailed data sheet wherever possible.*

Note:

i. *Bidder to attach certificates in support of declarations made here-in-above.*

ii. *Bidder may furnish additional information with regard to above Qualification Requirement by attaching separate sheets duly filled in the above format for such additional claimed works.*

SUMMARY OF FULFILMENT OF TECHNICAL CRITERIA

(To be submitted by the Bidder)

Qualifying Criteria	Reference (Page No.)
A. General Experience	
Experience as a prime Contractor having successfully completed at least one Electro-Mechanical work in a hydropower project on EPC/turnkey basis of Contract Value not less than BTN/INR 6,000.00 million (Ngultrum/Rupees Six Thousand Million only), with minimum installed capacity of 400 MW in preceding twenty (20) years (start to finish) reckoned up to 28 days prior to bid submission deadline and which are in successful operation for at least two (2) years without any major operational issues reckoned from the taking over of the works. *To determine the value of work done by the Contractor during the last 20 years it shall be escalated at the rate of 5%, compounded annually.*	
B. Specific Experience	
Must have successfully carried out design, manufacturing, supply, erection and commissioning of the following Electro-Mechanical works in hydropower projects in preceding twenty (20) years (start to finish) reckoned up to 28 days prior to bid submission deadline and which are in successful operation for at least two (2) years without any major operational issues reckoned from the taking over of the works.:	
a) Vertical Pelton Turbine of minimum 100 MW unit capacity	
b) Synchronous Generator of minimum 120 MVA unit capacity	

Date_____ **Signature**_____

APPLICATION FORM - 5

Current Contract Commitments/Works in Progress

Name of the Company: *(Sole Bidder or Partner of a joint venture/consortium and/or Sub-contractor(s))*

Maximum value of Electro-Mechanical works executed in any one year during last five years (at current price level) for projects completed/under execution: .....

Bidder should provide information about maximum value of works executed in any one year during last five years and their current commitments on all EM contracts that have been awarded, or for which a letter of intent or acceptance has been received, or for contracts approaching completion.

Name of Contract	Description of works	Stipulated date of completion	Contract Value (equivalent BTN/INR)*	Value of outstanding work (BTN/INR equivalent)*	Estimated completion date
1.					
2.					
3.					
4					
5					
6.					
7.					
8.					
9.					
10.					

i) Exchange rate as on date of award of Contract.
ii) Mention exchange rate adopted.
iii) Bidder to attach certificates in support of declarations made here-in-above..

Date _____ **Signature** _____



APPLICATION FORM - 6

Calculations of Bid Capacity

Name of Company: *(Sole Bidder or Partner of a Joint Venture/Consortium and/or Sub-contractor(s))*

Bidder should provide following information and calculation of bid capacity based on information so submitted.

A = Maximum value of works executed in any one year during last five years (at current price level) for construction works completed/under execution *(Bidders to attach certificates in support of declaration made herein above)*		BTN/INR_____
N = Number of years prescribed for completion of the contract package under consideration/bidding	=	Nos.
B =. Value at current price level of existing commitments and ongoing works to be completed in the next 'N' year	=	BTN/INR_____
Available Bid Capacity	=	BTN/INR_____

Date_____ **Signature**_____

APPLICATION FORM – 7

Litigation History

Name of the Company: *(Sole Bidder or Partner of a joint venture/consortium and/or Sub-contractor(s))*

Each Bidder or partner of a JV must fill in this form

Year	Matter in Dispute	Value of Pending Claims in BTN/INR Equivalent	Value of Pending Claims as a percentage of Net Worth

Date _____ **Signature** _____

INFORMATION FOR BIDDERS (IFB)

1. Project Profile and Scope of Work

1.1. Background

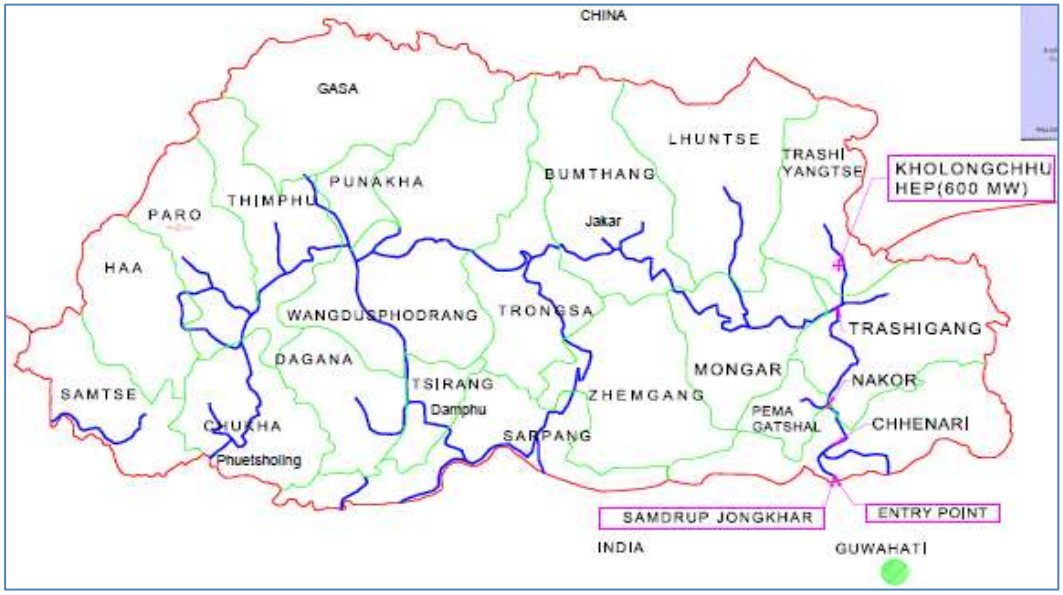
Detailed Project Report (DPR) for Khorlochhu Hydropower Project (KHPP) was prepared and completed on June 2011. The Final DPR was approved by CEA, GOI on November 5, 2012, and subsequently by the then Department of Hydropower & Power Systems (DHPS), RGoB on May 23, 2013.

Khorlochhu Hydropower Project (KHPP) is implemented through a strategic partnership between Druk Green Power Corporation (DGPC), Bhutan and Tata Power Company Limited (TPCL), India and is registered as "Khorlochhu Hydro Power Limited" under the Companies Act of Kingdom of Bhutan 2000, for execution of 4x150 MW KHPP.

1.2. Description of Khorlochhu HPP

KHPP is a run-of-the-river scheme hydropower project. It envisages construction of 95 m high concrete gravity Dam above deepest foundation level for diverting the Khorlochhu into the water conductor system. Two D-shaped underground Desilting Chambers of 300 m length and 13 m width each are located on the right bank of the river. This underground Desilting Chambers will be designed to remove the silt particles of size 0.2 mm and above. From the underground Desilting Chambers, 15.77 km long, 5.7 m diameter horse-shoe shape Head Race Tunnel (HRT) shall convey the design discharge of 89 cumecs water into the 2 Nos., 1.2 km long each circular Pressure Shaft with a diameter of 3.3 m and then into an underground Power House with four generating units of 150 MW each Pelton Turbines. A 1.522 km long, 6m diameter, D- shaped Tail Race Tunnel shall convey the turbine discharge back to Drangmechhu (Gongrichhu) river. The annual design energy generation at 90% dependable year with 95% plant availability is estimated at 2524.88 MU. The project is scheduled to be completed in 54 months after the award of main civil works.

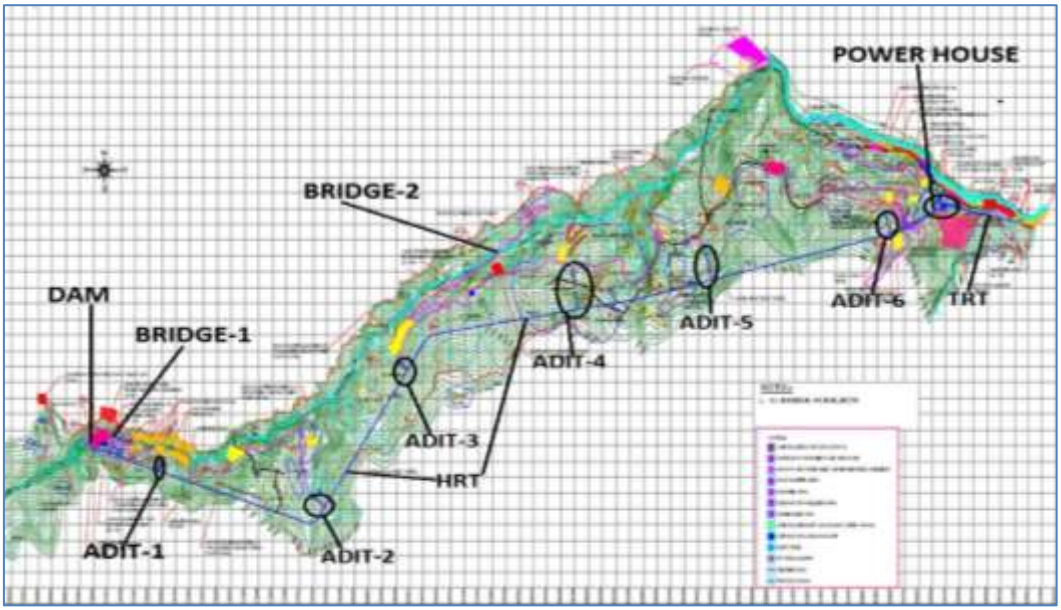
1.3. Project Location and Layout



The project area is partly located at the lower course of Khorlochhu River just before its confluence with Drangmechhu (Gongrichu) in Trashiyangtse Dzongkhag (District) of Bhutan touching upon the gewogs (blocks) of Yangtse, Tongzhang and Jamkhar. The water conductor system and all the project components are located along the right bank of Khorlochhu. The underground Power House

Khorlochhu Hydro Power Ltd.

is located on the right bank of Drangmechhu (Gongrichu), 5 kms downstream of Doksum town. The locations of the main project components are shown below.



1.4. Access to Project Sites

The Dam site is located near Buyang, 13 km downstream of Chorten Kora, Trashiyangtse Dzongkhag and the Power House is located on the right bank of Dramengchu (Gongrichu) at a place called Tshergom.

The nearest broad gauge railway station is Rangia (Assam), India about 270 km from Power House site. The nearest airport is at Guwahati (India) about 320 km. The Paro International airport in Bhutan is located at a road distance of 598 km from Power House site. From Rangia / Guwahati, the project is approachable by road via. Samdrup Jongkhar (Border town of India/Bhutan), Trashigang (Distt. Headquarter) and Chazam Bridge (junction of Trashigang - Thimphu road). The approximate distance of different locations from Guwahati is as under:

Guwahati to Samdrup Jongkhar/Daranga	= 110 Km
Samdrup Jongkhar to Trashigang	= 180 Km
Trashigang to Chazam	= 14 Km
Chazam to Power House Location	= 10 Km
Chazam to Doksum	= 15 Km
Doksum to Dam Site Location	= 17 Km
Doksum to Trashiyangtse	= 30 Km

1.5. Implementation of the Project and Contract Package

Khorlochhu Hydropower Project is being executed by Khorlochhu Hydro Power Limited (KHPL) through a strategic partnership between Druk Green Power Corporation (DGPC), Bhutan and Tata Power Company Limited (TPC), India, registered in Bhutan under Companies Act of Kingdom of Bhutan, 2000.

1.6. Scope of Works

The total works of project will be executed under International Competitive Bidding by splitting the project works into suitable Contract Packages e.g. Civil Works, Hydro-mechanical Works, Electro-mechanical Works (Package KEM-1 and KEM-2) etc. The scope of works for KEM-1 and KEM-2 are as defined below:

Khorlochhu Hydro Power Ltd.

a) **Contract Package KEM-1:**

The scope of work comprises the Design, Engineering, Manufacture, Inspection and Testing at Manufacturer's works, Supply, Transport, Insurance, loading/unloading, Storage (including development of storage area and facilities), Erection, Testing, Commissioning, Field Acceptance Test, Quality Assurance and training of purchaser's personnel for the following electro-mechanical equipment.

i) Turbine and Generator, including Governing system, Excitation system and other auxiliaries,
ii) Main Inlet Valves and Butterfly Valves,
iii) Isolated Phase Bus Duct (IPBD),
iv) Generator Transformers, Shunt reactor and Inter-Connecting Transformer (ICT),
v) 420kV Gas-Insulated Switchyard (GIS) system,
vi) 420kV and 145kV XLPE cables,
vii) Pothead Yard equipment,
viii) 132kV Switchyard (Incomer Bay for ICT),
ix) Balance of Plant (Electric Overhead Traveling (EOT) cranes, DC system, Uninterrupted Power Supply (UPS), MV and LV switchgear, Auxiliary transformers, Cables and cabling system, HVAC system, Diesel generators, Lubrication oil handling and purification system, Electrical and mechanical workshop equipment, Plant communication and public address system, Security and surveillance system, Fibre optic communication system, Lighting system, Drainage and dewatering system, Firefighting system, Low-pressure compressed air system and Grounding and lightning protection system)

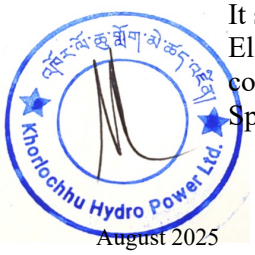
b) Contract Package KEM-2:

The scope of work comprises the Design, Engineering, Manufacture, Inspection and Testing at Manufacturer's works, Supply, Transport, Insurance, loading/unloading, Storage (including development of storage area and facilities), Erection, Testing, Commissioning, Field Acceptance Test, Quality Assurance and training of Employer's personnel for the following electro-mechanical equipment.

x) Control Systems:
- Unit Control Board,
- Common Control Board,
- Switchgear Control Board (SCB),
- Dam Control Board,
- HT/LT and 220VDC Control Board,
- BVC and Chaplangchhu Intake Control Board,
- TRT Control Board,

xi) Metering Panel,
xii) SCADA System, and
xiii) Protection System,

It shall also include the spares required for satisfactory operation and maintenance of Electro-mechanical equipment for a period of five years from the date of commissioning of the equipment as set forth in this Technical Specification and Specification Drawings.



The scope of work also covers unloading, stacking operation, storage and preservation of components of Electro-mechanical works under Contract Package KEM-1 and their accessories in the Contractor's stockyard at the Project.

1.7. Salient Features

Installed Capacity	600 MW (4X150 MW)
Location	
Country	Bhutan
District	Trashiyangtse
River	Khorlochhu
Nearest Village (Dam Site)	Buyang
Nearest Village (Power House Site)	Doksum
Access	
Airport	Paro (Bhutan)
	Guwahati (Assam, India) 320km
Rail Head	Rangia (Assam, India) 270km
Geographical Co-ordinate	
Dam Site	
Latitude (N)	27° 32' 50"
Longitude (E)	91° 30' 49"
Power House	
Latitude (N)	27° 24' 23"
Longitude (E)	91° 32' 57"
Hydrology	
Catchment Area at Diversion Site	1044 Sq.km
Snow Catchment (out of Total)	15 Sq.km
Maximum Observed Discharge at Dam site	929 cumecs
Minimum Observed Discharge at Dam site	10.3 cumecs
Probable Maximum Flood (PMF)	8750 cumecs
Average Annual Yield	1621 MCM
Reservoir	
Full Reservoir Level (FRL)	EL 1572.00 m
Minimum Draw Down Level (MDDL)	EL 1558.00 m
Water Spread at FRL	12.68 Ha
Gross Storage at FRL	2.9 MCM
Dead Storage at FRL	1.52 MCM
Live Storage	1.38 MCM
Length of Reservoir	1.4 km
Dam	
Type of Dam	Concrete Gravity Dam
Top Elevation of Dam	El. 1574.00 m
River bed level at Dam Site	El. 1512.00 m
Dam Height above River bed	62 m
Deepest Foundation Level	El. 1479.65 m
Maximum Height above Foundation Level	95 m
Length of Dam at Top	167 m
Top Width of Dam	9.5 m
Spillway	
Design Flood	8750 cumecs (PMF)

Khorlochhu Hydro Power Ltd.

Energy Dissipation System	Trajectory Bucket with naturally formed Plunge Pool
Lower Tier	
Type	Ogee with Sluice type
No. of Bays	5 Bays
Size of Gate	6.8 m (W) X 12.9 m (H)
Crest Level	EL. 1515.00 m
Upper Tier	
Type	Ogee with Open Crest
No. of Bays	1 Bay
Size of Gate	4.0 m (W) X 5.00 m (H)
Crest Level	EL. 1567.00 m
Diversion Tunnel	
Location of Diversion Tunnel	Left Bank
No. of Tunnel/s	1 No.
Size, Shape & Length of Tunnel	10.0 m Dia/Horse Shoe Shape/692.75 m
Diversion Discharge (25 years)	1112 cumecs
Inlet Invert Level	EL. 1518.00 m
Outlet Invert Level	EL. 1497.00 m
Diversion Tunnel Gate	4.5 m (W) X 10.0 m (H)
Power Intake	
Type	Straight Type with Incline Trash Rack
Number/s	2 Nos.
Design Discharge (All units running at full load including 20% of Flushing Discharge)	56.4 cumecs each
Invert Level	EL. 1546.65 m
Level at Centre of Tunnel	EL. 1549.00 m
Top Level	EL. 1574.00 m
Intake Feeder Tunnel	
No. of Tunnel/s	2 Nos.
Size of Tunnel	4.7 m Diameter
Shape of Tunnel	Horse Shoe Shape
Length	248 m & 283 m
Desilting Chamber	
Number/s	2 Nos.
Size	300 (L) x 13 (W) X 17.5 (H)
Average Design Discharge (with 10% Overload)	53.85 cumecs each
Maximum Particle Size to be Removed	0.2 mm and above
Silt Flushing Tunnel	
Main Tunnel	
Size of Tunnel	2.5 (W) X 3.5 (H)
Shape of Tunnel	D Shape
Length of Tunnel	97 m
Branch Tunnel	
Size of Tunnel	2.5 (W) X 2.2 (H)
Shape of Tunnel	D Shape
Length of Tunnel	125, 200 m
Head Race Tunnel	
Design Discharge	89.0 cumecs
Size of Tunnel	5.7 Diameter

Shape of Tunnel	Horse Shoe Shape
Length of Tunnel	16.23 km
Adits	6 Nos. 6.8 Diameter, D Shape
Chaplangchu Diversion	
FSL	EL. 1576.00 m
Design Discharge	5 cumecs
Trench Weir	24.0 m (L) X 3.0m (W) X 3.0 m (H)
Intake Invert Level	EL. 1574.30 m
Feeder Tunnel	2 (W) X 2.5 (H), 110 m Long
Desilting Chamber	6.0 m (W) X 6.5 m (H), 55.00 m Long
Inlet Tunnel to Drop Shaft	1.8 m (W) X 2.1 m (H), 194 m Long
Drop Shaft	2.5 Diameter, 104.0 m deep, Open to Sky
Connecting Tunnel - Drop Shaft to HRT	1.8(W) X 2.1(H), 485m Long
Surge Shaft	
Number/s	1 No.
Type	Restricted Orifice Type
Size & shape	9.5 m Diameter, circular
Height	162.8 m
Top Level	EL. 1650.00 m
Gates	2.75 (W) X 5.22 (H), 2 Nos.
Valve House	
Number/s	2 Nos.
Type	Butterfly Valve
Size of valve	3.3 m Diameter
Pressure Shaft	
Main Pressure Shaft	
Number/s	2 Nos.
Type	Circular
Size	3.3 m Diameter
Length	1,565.00 m (approx..) each
Branch Pressure Shaft	
Number/s	4 Nos.
Type	Circular
Size	2.35 m Diameter
Length	187 m Long
Power House Complex	
Type	Underground Power House
Location	Right Bank of Dramengchu (Gongrichu)
No. of Cavern/s	2 Nos.
Power House - Machine Hall	
Size	140.5 m (L) X 21.0 m (W) X 44.5 m (H)
Type of Turbine	Pelton Wheel
Number/s	4 Nos.
Capacity	150 MW each
Distributor Centre line Level	EL. 772.50 m
Turbine Floor Level	EL. 775.00 m
Generator Floor Level	EL. 779.50 m
Service Bay Floor Level	EL. 784.00 m
Maximum Tail Water Level	EL. 768.00 m
Design Head	761.53 m (net)
Transformer Hall, GIS cum TRT Gate Operation Cavern	

Facilities	Transformer Hall, GIS, TRT Gate Operation
Size	124.5 m (L) X 16.0 m (W) X 26.5 m (H)
Transformer Hall Floor Level	EL. 784.00 m
Access Tunnels (PH Complex)	
Main Access Tunnel (MAT)	
Size, Shape & Length	8 m Diameter, D Shape, 257.00 m long
Cable Access Tunnel (CAT)	
Size, Shape & Length	6.5 m Diameter, D Shape, 205.00 m long
Ventilation Tunnel	
Size, Shape & Length	6.5 m Diameter, D Shape, 102.96 m long
Drainage Gallery	
Size, Shape & Length	2.5 x 4.0 m, D Shape, 457.15 m long
Access Tunnel	
Size, Shape & Length	7 m Diameter, D Shape, 50 m long
Escape Tunnel	
Size, Shape & Length	3 m Diameter, D Shape, 50 m long
Tail Race Tunnel	
Unit TRT	
Number/s	4 Nos.
Type	D Shape
Size	4.00 m (W) X 4.50 m (H)
Length	605.19 m Long
Main TRT	
Number/s	1 Nos.
Type	D Shape
Size	6 (W) X 6 (H) m
Length	1798.41 m Long
Power Generation	
Design Energy in 90% Dependable year with 95% Plant availability	2524.00 MU
Annual Load Factor	48.02%
Construction Period	54 months

2. Transportation and Communication Facilities

The following information and data is provided by the Employer in good faith. Applicant should check for themselves during preparatory site visit as to correctness of information

2.1. Transportation

2.1.1. Rail Head

The nearest broad gauge rail Head is at Rangia (Assam), India which is about 270 km from Power House site.

2.1.2. Access to the Project and Road within Project Area

The project is approachable by road from Rangia/Guwahati via Samdrup Jongkhar (border town of India/Bhutan), Trashigang (district headquarter) and Chazam Bridge (junction of Trashigang -Thimphu road).

The different components of Project are accessible by various Project Access Roads, which shall be maintained by Contractors of Civil Works Packages. The Contractor of Hydro Mechanical Packages shall coordinate with Contractors of Civil Works Packages for use of Project Access Roads.

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2.1.3. Specifications of Access Road

The term 'Project Road', 'approach road' and 'access road' referred to in this document are synonymous and shall mean 'Access Road'.

Sl. No	Specification	Details
a	Formation Width	5.4 m except road to dam site which is 7.5 m.
b	Carriage way Width	4.0 m. for all roads except road to Dam site which is 6.0 m.
c	Shoulder Width on one side	0.5m
d	Drains	Lined V-shaped drain (600x300)mm
e	Load Classifications IRC class	40 R (wheeled / Tracked)
f	Pavement	WBM

2.1.4. Bridges (Project Area)

Sl. No	Location	Bridge Type	Span (m)	Carriage way width (m)
a	Khorlo Zam (Bridge at Dam Site)	Bailey Bridge	42	4.25
b	Shali – Tongzhang Zam (Bridge near Shali)	Bailey Bridge	42	4.25

2.2. Communication

Mobile phone facility is available in and around Trashiyangtse Dzongkhag (District). The contractor will install communication system on his own for reliable communication and shall be responsible for all issues related to frequency, license and mandatory compliances.

3. Hydrology

3.1. Basin Characteristics

Khorlochhu is a tributary of Drangmechhu (Gongrichu), which in turn is a tributary of river Manas. It originates from the snowy range along the northern Bhutan frontier. It generally flows in the southern direction up to the diversion site. The elevation at diversion site is EL 1512 m. The catchment falls between latitude 27^0 27' 00'' N to 27^0 57' 56'' N and Latitude 91^0 18' 36'' E to 91^0 39' 36'' E. The catchment area up to Diversion site is 1044 sq.km including snow fed catchment of 15 sq. Km (approximately). The catchment area of Chaplangchhu at diversion site is 40 sq.km.

3.2. Precipitation Characteristics

In the monsoon months this region receives major precipitation in the form of rainfall from June to October. During the winter season, the higher region of Himalayas receives precipitation in the form of snow while moderate rainfall occurs in the foothills and adjoining plains.

Average Ten daily discharge series for Khorlochhu Hydropower Project have been considered on the basis of ten daily discharge data of river Khorlochhu at Trashiyangtse and Muktirap located slightly upstream of the diversion site for period 1987 – 1998 and 2001 – 2010 respectively. The water availability at diversion site has been derived from the above data on the basis of catchment area proportion.

3.3. Design Flood

The floods in the river Khorlochhu are generally due to monsoon rains and melting of snow during summer months. Estimation of design flood has been done by several combinations of metrological and hydrological factors that are applicable in the region. The design flood is determined by Clarks approach, Dimensionless UG and frequency analysis. The design flood has been estimated as 8750 cumec at diversion site.

3.4. Sediment

Himalayan rivers are well known to bring lot of sediments during floods. Sediment observations have been made for Khorlochhu River since 2010.

4. Seismicity

The project area falls in Zone-V of Seismic Zone Map of India.

5. Power Potential Studies

As per CERC guidelines the 50% and 90% dependable years are determined by arranging unrestricted annual energy in descending order. Installation of 600MW capacity comprising 04 units of 150 MW each Pelton wheel turbine is proposed.

6. Power Plant

Khorlochhu Hydropower Project envisages installation of four units, each of 150 MW in underground Powerhouse. Main equipment comprises of 4 nos. of Pelton wheel turbines & main inlet valve of butterfly type complete with unit auxiliaries, 13 nos. single phase transformer. Design discharge and net head are 89 cumec and 761.53 m respectively.

7. Power Evacuation Aspects

The power evacuation system has been planned as per NTGMP by the Central Electricity Authority (CEA) and RGoB as a part of Integrated Power Evacuation Plan for all the power plants being set up in Bhutan in near future. As per this plan, two single circuit 400kV transmission lines on two double circuit towers will take off from Pothead yard of Khorlochhu HP Project and terminate at Yangbari Substation about 70 km from the Project.

8. Environment Aspects

There is negligibly small displacement of population from the project site. The project has been approved by the National Environment Commission (NEC), Royal Govt. of Bhutan for environment clearance.

9. Main Civil Works

a) **KC-1:** Construction of concrete gravity Dam, diversion tunnel, inlet & outlet portals, gate & plug, Spillway & Cofferdams, Intake Structure, Intake Tunnels, Branch HRT, Silt Flushing Tunnel (SFT), Branch SFT, Adit to Desilting Chambers (DC), Adit to Gate Operating Chambers (GOC) of DC, Gate operating Chambers of Desilting Chambers, Adit to GOC of SFT, GOC of SFT, Gate Shaft and 2 nos. Desilting Chambers, Adit-I and HRT (RD 0 to RD 2303 m).

b) **KC-2A:** Construction of Head Race Tunnel (HRT) from RD 3,941.34 m (18.85 m downstream of Adit II) to 14,091.07 m including Construction Adits III, IV and V.

c) **KC-2B**: Construction of Head Race Tunnel (HRT) from RD 2,303.00 m to 3,941.34 m (up to 18.85 m downstream of Adit II), Adit II to HRT and Chaplangchhu Diversion Works.

d) **KC-3A:** Construction of Pressure Shafts, Powerhouse Complex and Tailrace Tunnel.

e) **KC-3B:** Construction of Head Race Tunnel from RD 14,091.07m to RD 15,762.80m including Construction Adit-VI, Surge Shaft and Butterfly Valve Chamber.

10. Hydro Mechanical Works

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The hydro mechanical equipment comprising gates, hoist, stop logs, cranes, valves, pressure shaft liners etc. are provided on the Dam, intake and other structures for storage, controlled, discharge, generation of power etc.

11. Construction Power

The power at 33kV shall be provided near all Adit Portals of HRT and Pressure Shafts, Dam site, Surge Shaft and Powerhouse site each at a single point. The Contractor shall bear all the charges for internal arrangement and consumption of grid power which shall be taken at 33kV bus. The contractor shall also make necessary arrangements for standby power. The domestic electricity tariff rate and miscellaneous charges are available on the website https://www.bpc.bt/electricity-tariff/

12. Other/Miscellaneous

i) General Climatic Conditions in the Project Area

Bhutan's climate is influenced mainly by the monsoon wind, which blows from the Bay of Bengal. Local topography and the variations in elevations affect the climate as one moves from south to the north. In general, the climate is characterized by dry winter and wet summer monsoon and the temporal variations in climate are correspondingly extreme. The climate in Trashiyangtse (Eastern Bhutan) tends to be semi tropical with very cool winters. The summer monsoon last from June to September with heavy rains & high humidity. The coldest months in the region are December, January and February when the minimum temperature drops below freezing point. The warmest months are those from July to September when the maximum temp varies between 32º C to 35 º C with average being 28 º C.

ii) Port Facilities

For handling of imported machinery, nearest available port is at Kolkata, from where equipment can be transported through broad gauge rail network up to Rangia and from Rangia to project site by road.

iii) Availability of Land to the Contractor

The land will be provided to the Contractor for the construction of the project. Land shall also be made available to the contractor for developing temporary infrastructures, job facilities, power supply, communications etc., free of cost. In case any additional land is required for infrastructure works, the same will be arranged by the contractor at his own cost.

The Contractor has to make his own arrangements to develop infrastructure for their men and material required during construction period. The necessary residential and labour camps including other facilities like water supply, sanitation etc. shall be developed by the contractor at his own cost. All the camps, facility area, main works area etc. shall be fenced and protected by the contractor at his own cost.

To kick start the execution of the work immediately upon award of contract, certain access roads may be provided at no cost to the Contractor on as is where basis.

iv) Drinking Water Arrangement

The requirement of water for drinking and construction purpose will be met from the nearby natural sources/Nalah as per suitability. Main source of water supply is river water. Water for construction and potable water for the township shall have to be arranged by the Contractor at his own cost. Further, charges and clearance/arrangement with stakeholders, if any, leviable for usage of water from any source for construction/drinking purpose by the local authorities including charges for any facility which is required to be created shall be borne by the Contractor.

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v) Medical facilities

There is a Dzongkhag (District) level hospital at Trashiyangtse and Primary Health Center at Tshenkharla.

vi) School

Three Central Schools up to 12th standard are available in and around the Project area. In addition to this, there are also several primary schools available in the project area.

vii) Bank

Branches of Bank of Bhutan are available at Trashiyangtse and Doksum. In addition to this, Bhutan National Bank & Bhutan Development Bank is also functioning at Trashiyangtse.

viii) Insurance

Royal Insurance Corporation of Bhutan (RICB) has its office at Trashiyangtse presently.

ix) Work permit for contractors and his workmen

Work permit is required for foreign nationals to work in Bhutan. Contractor has to arrange work permit for his manpower at his own level. The Employer shall assist contractor in obtaining work permits. The contractor shall diligently comply with rules/regulations of the RGoB authorities.

x) Available of nearest fuel Station.

The nearest fuel station is available in Doksum, Trashiyangtse. In addition to this a fuel station is also available in Trashigang, which is about 60 km from Trashiyangtse, 30 km from Doksum and 25 km from Power House site. The contractor shall make arrangement for his own fuel station having sufficient storage capacity for meeting his petrol and HSD requirement, subject to adherence to applicable regulations.

xi) Manpower

The Contractor is encouraged, to the extent possible and reasonable, to employ staff and labour with appropriate qualifications and experience from Bhutan. To the extent possible, the unskilled labour shall, in principle, be recruited from this region.

The Employer may impose certain restrictions on the Contractors to deploy staff and labour as per the Laws of country. The Contractor shall not employ any person who has not completed 18 years of age. The Contractor shall arrange permits for the labour/staff for their entry into Bhutan, at his own cost.

13. Factors Influencing Construction

The constraints, not limited to those listed below, may be faced during the execution of the project for which Employer shall assume no responsibility and Contractor shall take appropriate measures at his own cost for completion of Works within Time for Completion:

a. Remote location of the project involving long road transport.

b. High precipitation in the project region particularly during monsoon season which extends from June to October. The road network and other infrastructure may be affected (due to landslides, flood and breaching of roads) during monsoon season leading to disruption of normal activities.

c. Frequent landslides and blockade of highway and other approach roads including restrictions on the bridges.

d. Power failures, voltage fluctuations and quality of power available.

Besides the above constraints which have been informed to the bidders in good faith, the bidders should ascertain for themselves about the extent of the above constraints and other constraints/obstructions likely to be encountered during execution of works.

14. Construction Period

The construction period of Main Civil, Electro-mechanical (KEM-2) and Hydro-mechanical Works is scheduled to be completed as under:

Package No.	Description of Work	Completion Period (Months)
KC-1	Construction of river diversion works, Dam, Intake, Desilting arrangement and HRT from RD 0.00 m to RD 2,303.00 m including Construction Adit I	54
KC-2A	Construction of Head Race Tunnel (HRT) from RD 3,941.34 m (18.85 m downstream of Adit II) to 14,091.07 m including Construction Adits III, IV and V.	54
KC-2B	Construction of Head Race Tunnel (HRT) from RD 2,303.00 m to 3,941.34 m (up to 18.85 m downstream of Adit II), Adit II to HRT and Chaplangchhu Diversion Works.	54
KC-3A	Construction of Pressure Shafts, Power House Complex and Tailrace Tunnel.	54
KC-3B	Construction of Head Race Tunnel from RD 14,091.07m to RD 15,762.80m including Construction Adit-VI, Surge Shaft and Butterfly Valve Chamber.	54
KEM -2	Design, engineering, manufacturing, fabrication, shop assembly, painting, testing at works, transportation, supply, erection, testing and commissioning of control and protection system.	42
KHM	Design, engineering, manufacturing, fabrication, shop assembly, painting, testing at works, transportation, supply, erection, testing and commissioning of Hydro-mechanical works.	42

15. Sacred Cultural/Religious Sites

The Contractor shall execute all activities in line with the guidelines of the Department of Culture, RGoB and the Guide and location map of Sacred Cultural/Religious Sites which contain the details of sacred sites/objects/monuments in the project area provided by the employer. The contractor shall take specific measures as may be warranted for physical and spiritual preservation of sacred cultural/religious sites/monuments. Under no circumstances, whatsoever, the contractor shall cause any damages to such sacred cultural/religious sites or monuments in the vicinity of the project by any construction activity particularly blasting. Extraction of construction materials such as boulders and timber from nearby such sacred sites shall not be permitted. Due reverence shall be exhibited by the contractor and its employees towards these sacred monuments and the religious sentiments of the local people shall be respected at all times.

The contractor shall ensure proper sanitation in and around the sacred sites. No wastes of any kind shall be disposed near the sacred sites. It shall be the responsibility of the contractor to make workers aware about the sacred sites. The behavior such as substance abuse, sexual misconducts and other nuisances in the vicinity of sacred sites is prohibited. The contractor shall not bar the public from visit to sacred sites unless written notices are fitted with the approval of the Employer and the contractor shall treat any public visiting the sacred sites with courtesy.

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Smoking, drinking, sexual activities, slaughter of animals etc. by the contractor or its staff and its business associates/partners in the vicinity of sacred sites and public places are prohibited.

CONSTRUCTION SCHEDULE

The Bidder shall be required to submit with its bid a detailed program, normally in the form of a bar chart, showing how and the order in which it intends to perform the Contract and showing the Milestone Dates and major events requiring action or decision by the Employer.

In preparing this Program, the Bidder shall adhere to the Time(s) for Completion given in the Bid Data Sheet or give its reasons for not adhering thereto. The Time Schedule submitted by the selected Bidder and amended as necessary prior to award of Contract shall be included as Appendix to the Contract Agreement before the Contract is signed.

KHORLOCHHU HYDRO POWER LIMITED

4x150 MW KHORLOCHHU HYDROPOWER PROJECT

TRASHIYANGTSE; BHUTAN

BIDDING DOCUMENT

FOR

CONTRACT PACKAGE: KEM-1

DESIGN, MANUFACTURING, SUPPLY, INSTALLATION, TESTING AND COMMISSIONING OF ELECTRO-MECHANICAL WORKS

VOLUME - 2

GENERAL CONDITIONS OF CONTRACT, PARTCULAR CONDITIONS OF CONTRACT, APPENDIX TO TENDER AND FORMS & PROCEDURES

International Competitive Bidding

These documents are meant for the exclusive purpose of bidding against this NIT and shall not be transferred, reproduced or otherwise used for purposes other than that for which they are specifically issued.

Tender Ref. No. KHPL/C&PD/TENDER:KEM-1/2025/11534 dt. 07.08.2025

LAYOUT OF BIDDING DOCUMENTS

CONTRACT PACKAGE: KEM-1

Design, Manufacturing, Supply, Installation, Testing and Commissioning of Electro-Mechanical Works

Volume - 1: Instructions to Bidders (ITB)

- Section - 1 Abridged Notice Inviting Tender and Notice Inviting Tender (NIT)
- Section - 2 Instructions to Bidders (ITB), Bid Data, Qualification Forms, Information for Bidders (IFB) and Work Schedule

Volume - 2: General Conditions of Contract (GCC) and Particular Conditions of Contract (PCC)

- Section - 3 FIDIC General Conditions of Contract (GCC) for Plant and Design-Build Contract (First Edition 1999)
- Section - 4 Particular Conditions of Contract (PCC) and Appendix to Tender
- Section - 5 Forms and Procedures
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  - Form-2: Form of Contract Agreement
  - Form-3: Bank Guarantee Form for Performance Security
  - Form-4: Bank Guarantee Form for Advance Payment
  - Form-5: Form of Taking Over Certificate
  - Form-6: Bank Guarantee Form for Release of Retention Money
  - Form-7: Hindrance Register
  - Form-8: Dispute Adjudication Agreement
  - Form-9: Parent/Holding Company Agreement
  - Form-10: Proforma for Joint Deed of Undertaking

Volume-3: Price Schedules

Volume-4: Employer's Requirements

- Section - 6 General Technical Specifications (GTS)
- Section - 7 Particular Technical Specifications (PTS)
- Section - 8 Quality Assurance Plan (QAP)

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SECTION – 3:

GENERAL CONDITIONS OF CONTRACT (GCC)



SECTION - 3: GENERAL CONDITIONS OF CONTRACT (GCC)

The General Conditions of Contract (GCC) shall be those stipulated in the FIDIC Conditions of Contract for **"Plant and Design-Build Contract (First Edition 1999)"**, for Electrical & Mechanical Plant and for Building & Engineering Works Designed by the Contractor, prepared by the ***Federation Internationale des Ingenieurs - Conseils (FIDIC).***

These Conditions are subject to the variations and additions set out hereof entitled **"Particular Conditions of Contract (PCC)"**.

A copy of the General Conditions of Contract is not included with the Bid Documents for the works and reference should therefore be made to the published FIDIC document.

In accordance with Clause 33.1 of Instructions to Bidders, the Contractor shall provide 15 (fifteen) sets of the original FIDIC Conditions of Contract in the required format as directed by the Employer.

Copies of the FIDIC Conditions of Contract (Yellow Book First Edition 1999) can be obtained from https://fidic.org/books/plant-and-design-build-contract-1st-ed-1999-yellow-book and from:

FIDIC – International Federation of Consulting Engineers
World Trade Center II - Geneva Airport
P. O. Box 311
CH-1215 Geneva 15
Switzerland
Website: www.fidic.org

SECTION - 4

PARTICULAR CONDITIONS OF CONTRACT (PCC)



SECTION - 4: PARTICULAR CONDITIONS OF CONTRACT (PCC)

The following "Particular Conditions of Contract (PCC)", which include amendments and additions to the General Conditions of Contract (GCC) shall supplement the GCC. The General Conditions of Contract (GCC) are linked with the Particular Conditions of Contract (PCC) by the corresponding numbering of the Clauses, so that GCC and PCC together comprise the conditions governing the rights and obligations of the parties. In case of any inconsistency between the conditions contained in GCC and those in PCC, the conditions contained in PCC shall prevail over those of GCC.

1. General Provisions	
1.1 Definitions	
1.1.1 The Contract	
1.1.1.5	*At the end of Sub-Clause 1.1.1.5, insert:* The words "Employer's Requirements" are synonymous with "Technical Specifications", "General Technical Specifications (GTS)", and "Particular Technical Specifications (PTS)"
1.1.1.8	*At the end of Sub-Clause 1.1.1.8, insert:* The word "Tender" is synonymous with "Bid".
1.1.4 Money and Payments	
1.1.4.8	*At the end of Sub-Clause 1.1.4.8 insert:* "BTN" or "Ngultrum" means Bhutanese Ngultrum, legal tender of the Kingdom of Bhutan . "INR" or "Rupees" means Indian Rupees, legal tender of the Republic of India. "EUR" or "Euro" means the legal tender of the EU Member Countries.
1.1.5 Works and Goods	
1.1.5.1	*At the end of Sub-Clause 1.1.15, insert:* The words "Construction Equipment" or "Equipment" are synonymous with "Contractor's Equipment."
1.1.6 Other Definitions	
1.1.6.8	*Delete 1.1.6.8 and substitute by the following:* Unforeseeable means not reasonably foreseeable physical ground conditions by an experienced contractor. This shall not include conditions other than ground conditions.
	At the end of Sub-Clause 1.1.6.9, insert: 1.1.6.9.1 "**Milestone**" means an intermediate event or landmark identified in the Contract, which is critical for Completion of Works within Time for Completion. Milestone shall not be construed to mean Section of Works. 1.1.6.9.2 "**Integrity Pact**" means the Pact signed between the Employer and Contractor committing the persons/officials of both the parties, not to exercise any corrupt influence on any aspect of the Tender/Contract.



	1.1.6.9.3 "**RGoB**" means Royal Government of Bhutan. 1.1.6.9.4 "**Agents / agent**" are / is a person(s) engaged by another person (called the "principal") to do any act on behalf of the principal or to represent the principal in dealings with third parties. It does not include the vendor(s) or any other persons nominated or approved through the Employer.
1.2 Interpretation	*At the end of Sub-Clause 1.2, add:* In these Conditions, provisions relating to the expression "Cost plus reasonable profit" for example in GCC Clause 1.9, 2.1, 4.7, 7.4, 10.2, 10.3, 12.2, 12.4, 16.1, the term "plus reasonable profit" shall be taken as nil and accordingly the words "Cost plus reasonable profit" shall be substituted by the word "Cost."
1.5 Priority of Documents	The documents forming the Contract are to be taken as mutually explanatory of one another. If an ambiguity or discrepancy is found, the priority shall be such as may be accorded by the governing law. The Engineer has authority to issue any instruction which he considers necessary to resolve an ambiguity or discrepancy. *Delete the documents listed from (a) to (h) in Sub-Clause 1.5 and substitute by:* a) the Contract Agreement (if completed), b) the Letter of Acceptance, c) the Letter of Tender, d) Appendix to Tender e) these Particular Conditions f) these General Conditions, g) the Employer's Requirements h) the Tender Drawings, i) the Price Schedules, j) the Data Sheets, k) the Information for Bidders, l) the Contractor's proposal, and m) any other documents forming part of the Contract.
1.8 Care and Supply of Documents	*In the first paragraph, replace 2nd sentence as under:* The Contractor shall supply to the Engineer (5) hard copies-original and two (2) electronic copies (out of which one electronic copy shall be in source format/software in editable format). *At the end of Sub-Clause 1.8, add the following:* In the preparation of the calculations and drawings, the Contractor shall anticipate and be responsible for updating the Contractor's Documents to incorporate: (i) changes to suit modifications arising from the encountered conditions revealed during construction, including instructions issued by the Engineer; (ii) drawing revisions issued by the Engineer; and (iii) drawings issued by other Contractors and arising from the specified liaison with other Contractors.
	After Sub-Clause 1.14, add new Sub-Clause 1.15 as below:



1.15 Severability	If any provision or condition of the Contract is prohibited or rendered invalid or unenforceable by law, such prohibition, invalidity or unenforceability shall not affect the validity or enforceability of any other provisions and conditions of the Contract.
2. The Employer	
2.1 Right of Access to the Site	*Replace the word "Cost plus reasonable profit" appearing at the end of the third paragraph under this clause by the word "Cost" only.*
3. The Engineer	
3.1 Engineer's Duties and Authority	*Add the word "one of its Employee(s) as" after the word "appoint" in the 1st line of 1st para.* *At the end of Sub-Clause 3.1, add the following paragraphs:* Any consultation that the Engineer holds with the Employer in pursuant to the Contract shall be entirely an internal matter between the Engineer and the Employer. The recommendations and determinations by the Engineer are subject to review and finalization by the Employer. The same shall not be subject to matter of reference either by the Contractor or any arbitral Tribunal. The requirement, in the various Sub-Clauses of GCC and these Conditions of Contract, to consult and/ or to notify the Employer of all the instructions, actions and correspondences of the Engineer with the Contractor is dispensed with. The Engineer shall obtain the specific approval of the Employer before taking action under the following Sub-Clauses of GCC and these Conditions: (a) consenting to the subletting of any part of the Works under Clause 4.4; (b) Determining an extension of Time for Completion under Clause 8.4; (c) Sub-Clause 4.12: Agreeing or determining of Delay and/or Cost, (d) Sub-Clause 13.1: Instructing a Variation, except; i) in an emergency situation as determined by the Engineer, or ii) if such a Variation would increase the Accepted Contract Amount by less than the percentage specified in the Contract Data (e) Sub-Clause 13.3: Approving a proposal for Variation submitted by the Contractor in accordance with Sub-Clause 13.1 or 13.2; Notwithstanding the obligation, as set out above, to obtain approval, if, in the opinion of the Engineer, an emergency occurs affecting the safety of life or of the Works or of adjoining property, he may, without relieving the Contractor of any of his duties and responsibilities under the Contract, instruct the Contractor to execute all such work or to do all such things as may, in the opinion of the Engineer, be necessary to abate or reduce the risk. The



	Contractor shall forthwith comply, despite the absence of approval of the Employer, with any such instruction of the Engineer. The Engineer shall determine an addition to the Contract Price, in respect of such instruction, in accordance with Clause 13 and shall notify the Contractor accordingly."
3.5 Determinations	*At the end of Sub-Clause 3.5, add:* Determination of Cost related to extension of time for completion referred in clause 1.9, 2.1, 4.7, 4.12, 4.24, 7.4, 8.9, 10.3, 11.8, 16.1 & 19.4 for the purpose of determination referred to in GCC or these conditions "reasonable profit" wherever referred to shall be treated as nil and "Cost" shall be determined as per mechanism provided for in **Appendix to Tender (Annexure-I)**. The determinations under this Sub-Clause shall, however, be subject to provisions of Sub-Clause 3.1. The cost claims related to extension of time for completion (if admissible under the contract) shall be limited to the losses suffered/cost incurred during the hindrances of contemporary period. No claim shall be payable related to consequent effects/cost in extended stay period.
4. The Contractor	
4.1 Contractor's General Obligations	Delete the first paragraph and replace with: "The Contractor shall design, execute and complete the Works and shall remedy any defects in the Works in accordance with the Contract, including: (a) Best Industry Practices, (b) all applicable Laws and the terms of any licenses, permits and consents, (c) the Technical Specifications, and (d) the Programmer. The Contractor shall warrant that, when completed, the Works shall be fit for purpose for which the Works are intended as described in the Contract." Between the fourth and fifth paragraph insert: "The Contractor shall conduct his operations in such a manner as to avoid injury or damage to adjacent property or facilities. The Contractor shall note that this responsibility shall apply to the whole of the land or facilities occupied or used by him for the purpose of the Works." *At the end of this Sub-Clause add the following:* The Contractor's obligations shall extend to any interfaces between his works and those of Other Contractors. A Tripartite Interface Agreement shall be signed between KHPL and Contractor(s) of KEM-1 and KEM-2, during execution of the works or after issuance of LoA for respective Contract Packages.
4.2 Performance Security	*Delete first paragraph of Sub-Clause 4.2.1 and substitute by the following paragraphs:*

	The Contractor shall deliver Performance Security to the Employer with a copy to the Engineer within 28 days of issue of Letter of Acceptance. The Performance Security shall be in the form of a bank guarantee for the amount stipulated by the Employer as under: In case Bidding Company (subsidiary company) gets qualified and awarded the work package on the strength of Parent/Holding Company, the Parent company / holding Company (registered in India/Bhutan) shall furnish an additional unconditional Performance Bank Guarantee of value equivalent to five (5) percent of the Accepted Contract Amount, in addition to normal Performance Bank Guarantee to be submitted by the Bidder to the Employer besides entering into a separate Agreement in the requisite Format provided in the Bid Document. The Contractor who are qualified on the strength of their Subcontractor shall be required to furnish an additional Performance Bank Guarantee from their Subcontractor within 28 days of issue of Letter of Acceptance, if required, under the Contract. The Performance Security shall be in the form of a Bank Guarantee, as stipulated by the Employer in **Section-5: Forms and Procedures, Form-3**. The Performance Security shall be denominated in the types and proportions of currencies in which the Accepted Contract Amount is payable. In case of Bidders not having requisite experience of Design, is engaging Design Consultant having prior experience of similar works, such consulting company shall be required to furnish an additional performance bank guarantee to zero-point five percent (0.5%) of the Accepted Contract Amount in addition to normal Performance Bank Guarantee to be submitted by the Bidder to the Employer. The performance bank guarantee provided by the Contractor and/or Parent Company shall be valid up to Ninety (90) days beyond Defect Notification Period. The additional performance bank guarantee provided by Subcontractor shall be valid till completion of part of the Works executed by the Sub-contractor. The performance bank guarantee provided by the Design Consultant (if associated) shall be valid up to Ninety (90) days beyond Defects Notification Period. The Performance Security shall be denominated in the currency of bid. A Bank Guarantee either issued by a bank/financial institution in Bhutan or any nationalized/scheduled bank in India with endorsement/counter guaranteed by a bank/financial institution in Bhutan shall only be acceptable.
4.3 Contractor's Representative	*At the end of second paragraph of Sub-Clause 4.3, add:* "If Contractor's Representative is not, in the opinion of the Engineer, fluent in English, the Contractor shall have available on site at all times a competent interpreter to ensure the proper transmission of instructions and information."

4.4 Subcontractors	*Sub-Clause 4.4 is deleted and substituted by the following:* "The Contractor shall not subcontract any portion of the Works without the approval of the Engineer. Appointment of any Subcontractor and any subcontracting shall not relieve in any way or manner whatsoever the Contractor from any of its obligations, liabilities and responsibilities under the Contract. The Contractor shall be responsible for the acts and defaults of any Subcontractor/Manufacturer/Vendor and Employees, as if they were the acts and defaults of the Contractor. Save and except as set forth here-in-under, the Contractor shall give the Engineer not less than 60 (sixty) days' notice of: (a) The intended appointment of the Subcontractor, with detailed particulars which shall include his relevant experience and other details considered necessary by the Employer, (b) The intended commencement of the Subcontractor's work Notwithstanding the provisions contained in above, the consent of the Engineer shall not be required in respect of Sub-Contracting or Sub-letting of the following: (i) Provision of labour/Piece Rate Work (PRW), (ii) For Construction Equipment and Temporary Works, (iii) For clearance and/or transportation, The Contractor shall strictly adhere to and select and employ its Subcontractors/Manufacturer/Sub-vendor from the lists specified under **Section-5, Forms and Procedures, Form-1: Letter of Tender [Attachement-8].** Bidders can also suggest alternate names for inclusion into the list fulfilling the specific qualification criteria listed against those items as specified under **Section-5, Forms and Procedures, Form-1: Letter of Tender, [Attachment-9]**. The Contractor may from time to time propose any addition to or deletion from any such list. The Contractor shall submit any such lists or any modification thereto to the Employer for its approval in sufficient time so as not to impede the progress of work on the Facilities. Such approval by the Engineer for any of the Subcontractors/sub-vendors proposed by the Contractor or selection of any Subcontractors/sub-vendors by the Contractor from the list provided in the Bid Document, shall not relieve the Contractor from any of its obligations, duties or responsibilities under the Contract. The contractor shall also submit the list of Subcontractors for erection, testing and commissioning of the Works. The Subcontractors shall fulfill the specific qualification criteria listed under **Section-5, Forms and Procedures, Form-1:Letter of Tender [Attachment-10]**.
4.6 Co-operation	*Add the following new paragraphs at the end of this Sub-Clause:* "The Project involves other Contracts, including in particular the Civil and Hydro-mechanical Works for the execution of the various other Works on the Project which will be performed concurrently

	with the Works under this Contract. The Contractor shall co-ordinate his general day-to-day activities with the Employer's other Contractors to avoid hindrance and obstruction of the Employer's other Contractors as far as is appropriate and reasonable. This will include co-ordination and co-operation with the Employer's other Contractors at any interfaces between the Work of this Contract and the Work of the Employer's other Contractors and for joint use of facilities such as roads, site installation areas and other general site services. Such general co-operation shall be foreseen and provided for in the Contractor's programming and is deemed to be included in the Accepted Contract Amount."
4.7 Setting Out	*Substitute the last word "Cost plus reasonable profit" of Sub-Clause 4.7.3(ii) by the word Cost.*
4.8 Health and Safety Obligations	*After Sub-Clause 4.8, add the following:* f) "The Contractor shall be liable to be levied penalty for non-compliance or repeated failure in implementation of requisite safety measures as described above. The amount of penalty applicable for different types of violations shall be as specified under **Annexure-II of Appendix to Tender.** However, the cumulative limit for the penalty under a contract shall be 1.0 (one) percent of Accepted Contract Amount. This penalty shall be in addition to all other penalties specified elsewhere in the contract. If cumulative limit of penalty is exceeded but the Contractor continues to neglect the requisite safety measures, the same shall be considered as breach of contract. Such sums shall be deducted from any monies payable/due to the Contractor. No claim for levy of such penalty on account of non-observance of safety measures by the Contractor shall be entertained by the Employer. Further, imposition of penalty does not make the contractor eligible to continue the work in unsafe manner."
4.10 Site Data	*At the end of Sub-Clause, add point (f) to (g):* f) "Site conditions including access to the site, existing and required roads and other means of transport/ communication for use by them in connection with the Works; g) Requirement and availability of land and other facilities for their enabling works, colonies, stores and workshops etc. such land shall be arranged by the Contractor at his own cost, if not provided by the Employer."
4.11 Sufficiency of the Accepted Contract Amount	*At the end of Sub-Clause 4.11, add:* "Items of the works described in the Price Schedule for which no rate and price has been entered in the Contract shall be considered (up to the quantities provided in Price Schedule) as included in other rates and prices in the Contract and will not be paid separately by the Employer."
4.16 Transport of Goods	*At the end of Sub-Clause 4.16, add:*

	"The contractor shall give preference to Bhutanese for transportation of Goods for the project. The contractor shall show proof of adequate efforts made for such recruitment. If it is found necessary for the Contractor to move one or more oversized/overweight loads of Goods over roads, highways, bridges on which such oversized and overweight items are not normally allowed to be moved, the Contractor shall obtain prior permission from the concerned authorities. Project road constructed by employer/ civil contractor shall be used by the contractor on "As is where is Basis" for transport of goods. Project Roads constructed by Employer will be of WBM standard only. However, major parts of the Project Roads may be black topped (tarred) by the Civil Contractor. The contractor shall share with other contractors the use of project access roads"
4.17 Contractor's Equipment	*At the end of the Sub-Clause 4.17, add:* "If in the opinion of Engineer, the Equipment deployed by the Contractor are old/inapt for carrying out the works and the works are likely to be delayed due to deployment of such Equipment, the Engineer can ask the Contractor to replace such Equipment. Also, based on the nature and exigency of work, Engineer may direct the Contractor to deploy such additional Equipment as is deemed necessary for timely completion of Works without any extra payment whatsoever on account of replacement of old Equipment and/or deployment of additional Equipment."
4.18 Protection of the Environment	*At the end of Sub-Clause 4.18, add:* "The Contractor shall be required to ensure that there shall be no felling of trees or unauthorized quarrying by him or his labourers or their family members and he will be solely responsible for their acts in this regard. The Contractor shall maintain ecological balance by preventing deforestation, water pollution and defacing of natural landscape in the vicinity of work areas. The Contractor shall so conduct his construction operations as to prevent any unnecessary destruction of, scarring or defacing the natural surroundings in the vicinity of the work area. In order to maintain the ecological balance, the Contractor shall specifically comply with the following instructions: a) The Contractor shall strictly follow all notifications/guidelines of RGoB related to protection of Environment, conditions stipulated by the National Environment Commission (NEC), RGoB while according the environment clearances to KHPL and conditions stipulated in Technical Specifications. b) Where unnecessary destruction, scarring, damage or defacing may occur as a result of the Contractor's operation, the same shall be repaired, replanted or otherwise corrected at the Contractor's expense. The Contractor will prevent scattering of rocks and other debris outside the work areas. All work areas shall be smoothed and graded in a manner to conform to the natural appearance of the landscape as directed by the Engineer.



	c) All trees and shrubs which are not specifically required to be cleared or removed for construction purposes shall be preserved and protected from any damage that may be caused by the Contractor's construction operation and equipment. The removal of trees or shrubs will be permitted only after prior approval from the relevant authorities. Special care shall be exercised where trees or shrubs are exposed to injuries by Construction Equipment, blasting, excavating, dumping, chemical damage or other operation and the Contractor shall adequately protect such trees by use of protective barriers or other methods approved by the Engineer. Trees shall not be used for anchorage. d) The Contractor's construction activities shall be performed by methods that will prevent entrance or accidental spillage of solid matter contaminants, debris and other objectionable pollutants and wastage into the river. Pollutants and wastes shall be disposed-off in a manner and at sites in conformity with applicable Laws. e) In the conduct of construction activities and operation of Construction Equipment, the Contractor shall utilize such practicable methods and devices as are reasonably available to control, prevent and otherwise minimize air pollution. The Contractor shall fully comply with all applicable Laws in this regard. f) Burning of materials resulting from clearing of tree, bush, combustible construction materials and rubbish may be permitted only when atmospheric conditions for burning are considered favourable. g) Contractor (including its Sub-contractor) shall provide alternative fuel arrangement i.e. cooking gas/ kerosene oil, electricity free of cost to all its canteen /mess, labourers and staff working in the Project during the whole period of construction activity to avoid felling of trees for use as firewood. In case alternative fuels supply i.e. kerosene, gas, electricity is not available in the project area, the Contractor shall approach the Department of Forests and Park Services/Natural Resources Development Corporation Limited to open fuel wood depot in the project area for meeting the demand of fuel wood. h) The Contractor shall be required to prevent flowing of debris and muck into the river. Necessary retaining structures like walls/crates etc. shall be constructed for the purpose. The Contractor shall also stabilize the muck fully i.e. consolidation and compaction of the muck shall be carried out in the muck dump sites before handing it over to the Employer at the end of construction period. i) Medical facilities as well as the recreational facilities shall also be provided to the labourers. j) All labourers to be engaged for the construction work shall be thoroughly examined by health personnel and adequately treated before they are deployed in the work.



	k) All the Construction Equipment which are likely to generate high noise levels are to be fully equipped (with noise reduction measures) to meet the ambient noise control standards. l) The Employer shall facilitate/assist Contractors in obtaining necessary permits from concerned authorities/agencies of RGoB. The Contractor shall not allow any of its employee/labourers employed by it to settle in forest area even temporarily. If any provision(s) is not complied with within a reasonable time even after issue of a notice in this respect, the necessary operations would be carried out by the Engineer/concerned authorities of RGoB at the cost of the Contractor plus administrative charges of Employer. The Contractor shall indemnify and hold the Employer harmless against and from all claims, damages, losses and expenses (including legal fees and expenses) resulting from the consequences of any failure by the Contractor to comply with the provisions of this Sub-Clause. In addition, the contractor shall execute all activities in line with the guidelines of the Department of Culture, RGoB and the Guide and location map of Sacred Cultural/Religious Sites which contain the details of sacred sites/objects/monuments in the project area provided by the employer. The contractor shall take specific measures as may be warranted for physical and spiritual preservation of sacred cultural/religious sites/monuments. Under no circumstances, whatsoever, the contractor shall cause any damages to such sacred cultural/religious sites or monuments in the vicinity of the project by any construction activity particularly blasting. Extraction of construction materials such as boulders and timber from nearby such sacred sites shall not be permitted. Due reverence shall be exhibited by the contractor and its employees towards these sacred monuments and the religious sentiments of the local people shall be respected at all times. The contractor shall ensure proper sanitation in and around the sacred sites. No wastes of any kind shall be disposed near the sacred sites. It shall be the responsibility of the contractor to make workers aware about the sacred sites. The behavior such as substance abuse, sexual misconducts and other nuisances in the vicinity of sacred sites is prohibited. The contractor shall not bar the public from visit to sacred sites unless written notices are fitted with the approval of the Employer and the contractor shall treat any public visiting the sacred sites with courtesy. Smoking, drinking, sexual activities, slaughter of animals etc. by the contractor or its staff and its business associates/partners/ Subcontractors in the vicinity of sacred sites and public places are prohibited.”
4.19 Electricity, Water and Gas	*At the end of Sub-Clause 4.19, add:* “The construction power for the Project shall be arranged and provided to the Contractor by the Employer at 33 kV bus at various

	identified locations/construction sites. Step-down arrangement is to be made by the Contractor at its own cost. Contractor shall, along with its Bid, submit the power requirements in kVA at each working area location. Each supply point shall be treated as separate connection. Arrangements for further distribution of power to the Contractor's Site, fix equipment, workshops, colonies and offices from the point of supply shall be made by the Contractor at his own cost. The electrical installation plan shall be submitted for approval of the Engineer. Before the release of grid connection, the Contractor shall make all applicable advances/ fees/deposits at prevalent rates as per rules of RGoB to the Employer/ Bhutan Power Corporation (BPC), as the case may be. The domestic electricity tariff rate and miscellaneous charges are available on the website https://www.bpc.bt/electricity-tariff/ Contractor shall also make necessary back-up arrangements of construction power by installing sufficient number of diesel generating (DG) sets & lines and operate these sets for his requirements of power at no cost to the Employer. Permission for installation of DG sets shall be taken by the Contractor at his own cost as per applicable rules from concerned authorities in Bhutan. The Contractor shall comply with all the conditions of power supply rules and regulations prevalent in Bhutan. The Contractor shall pay the applicable energy charges to the concerned agencies from time to time. Any variation in power tariff as may be applicable during execution of Works, shall be borne by the Contractor and shall not be paid by the Employer separately under clause 13.7 of GCC (Adjustment for Changes in Legislation). No claims shall be entertained by the Employer on account of non-availability or inadequate quality of construction power. The Contractor shall ensure effective enforcement of the provisions under the Water Act of Bhutan 2011 and its Regulation 2014."
4.21 Progress Reports	*At the end of Sub-Clause 4.21, insert the following paragraph:* (i) List of all insurance claims lodged with the insurance companies showing details viz. nature and amount of claim lodged, status of settlement, reasons for delay in settlement of claim(s) (if any), amount settled and paid by insurance company, amount of settled claim paid or to be paid to the Employer (where Employer has interest in the claim) etc. (j) The Contractor/Engineer is required to maintain Hindrance Register(s) as per **(Section-5, Forms and Procedures-Form-7)** for reporting hindrances if any, while executing the work in respect of design, engineering, procurement, supply and site work related issues. The Contractor/Engineer shall record hindrances in the Hindrance Register(s) and Contractor shall bring each hindrance to the notice of Engineer not later than 7 days of the happening of the hindrance failing which the same shall not be considered or taken into account for any purpose whatsoever. The Contractor shall submit in the monthly progress report up to

	date hindrance record in the format as mentioned in the hindrance register with reference number and date of intimation of occurrence of each hindrance(s). (k) In case of any hindrance, if the Contractor's resources are idle, the Contractor shall get the same verified from the Engineer on a regular basis. Up to date duly verified idling of Manpower and Equipment shall be submitted by the Contractor in the format given in **Volume-6, Technical Data Sheets** and other supplementary formats as approved by the Engineer. The Contractor shall submit the above details along with reasons for such idling. (l) List of all the claims submitted by the Contractor. (m) List of the Construction Equipment brought at Site during the period with purchase invoices. Further, the Contractor shall submit annual report regarding the status of works undertaken in pursuance to the contract. In addition to other annual reports namely gist of progress during the year; photograph showing status of works at the end of the accounting year; details of the Contractor's personnel and equipment; details of claims preferred; safety statistics including hazardous accidents; main environment aspects; the Contractor shall also submit report on annual accounts of the works undertaken by the Contractor under the Contract as a separate accounting unit. The annual accounts shall be compiled in accordance with applicable accounting standards, audited by their statutory auditors/independent Chartered Accountant. The Contractor shall submit the audited annual accounts within 60 days from the end of accounting year.
	After 4.24, add new Sub-Clauses 4.25 and 4.26 as below:
4.25 Land	The Employer shall make available land as indicated in the tender drawings, free of cost, for construction of Contractor's construction facilities like temporary houses for staff and labour, field offices, workshop, stores, fabrication shops, etc. required for execution of the Contract. Levelling and dressing of the land for contractor's construction facilities as per plan approved by the engineer shall be done by the contractor at his own cost. Additional land, if required by the Contractor for construction facilities shall be arranged by him at his own cost. The Contractor shall obtain the environment clearances from concerned authorities as per provisions of the Environment Assessment Act, 2000 and its Regulations 2002 for setting up his construction facilities at his own cost. The Employer shall extend all necessary assistance to the Contractor to obtain required environment clearances. Levelling and dressing of the site and construction of temporary roads, houses, offices, workshops, etc. as per the plan approved by the Engineer shall be done by the contractor at its own cost. The Final payment Certificate shall not be issued, until and unless the Contractor has handed over the possession of land allotted to him in good condition after obtaining clearances from the relevant agencies of RGoB and free from all encumbrances. The use or occupation of the land by the Contractor shall not confer on him any right of tenancy or possession thereof. The Contractor

	shall vacate immediately land upon one month notice of the Engineer.
4.26 Assignment and Novation of Manufacturer's Warranties	The Contractor shall procure that any warranty, express or implied, with respect to any Plant or Materials used in the construction of the Works made or given by the manufacturer, any Subcontractor, any supplier, or any other seller thereof, will be made in favour of the Employer, or will be assigned or otherwise made available to the Employer or such entity that the Employer nominates. The Contractor must ensure that all warranties given by the manufacturer, Subcontractor or supplier, or any other seller thereof, will be capable of novation from the Employer to any entity to be nominated by the Employer. To the extent that the warranties cannot be made in favour of the Employer, assigned or otherwise made available to the Employer, the Contractor agrees (at its cost) to use its best endeavours to enforce such rights as the Contractor may have, for the benefit of the Employer. The Works shall not be considered to be completed for the purposes of being Taken Over under Sub-Clause 10.1 [*Taking Over the Works and Sections*] until the Employer has received such warranties and confirmation that the warranties are capable of novation from the Employer to any entity to be nominated by the Employer.
5. Design	
5.1 General Design Obligations	*Delete Sub-Clause 5.1 and substitute by the following paragraphs:* "The Contractor shall carry out, and be responsible for, the design of the Works consistent with Best Industry Practices. Design shall be prepared by qualified, experienced and competent designers who are engineers or other professionals who comply with the criteria (if any) stated in the Technical Specifications. Unless otherwise stated in the Contract, the Contractor shall submit to the Engineer for consent the name and particulars of each proposed designer and design sub-contractor. The Contractor shall at his own expense carry out all investigations, model studies, design and preparation of specifications, construction, working, shop drawings and all other things as necessary for the performance of the Works. The design and drawings shall be accompanied by detailed calculations, including design philosophy, references (if any) and standards, and shall be submitted to the Engineer, in accordance with Sub-Clause 5.2 [*Contractor's Documents*] and the Technical Specifications, for approval, before commencement of the Works. The Contractor shall be responsible for coordinating his detailed design with the Civil Contractor & Hydro-mechanical Contractor, failure to do so shall not entitle the Contractor to any extension of Time for Completion or any additional costs or other compensation. The Contractor shall warrant that he, his designers and design Subcontractors have the experience, capability and competence necessary for the design. The Contractor shall undertake that the

	designers shall be available to attend discussions with the Engineer at all reasonable times (on or off the Site), until the issue of the Performance Certificate. Upon receiving notice under Sub-Clause 8.1 [*Commencement of Works*], the Contractor shall scrutinise the Employer's Requirements (including design criteria and calculations, (if any) and the items of reference mentioned in Sub-Clause 4.7 [*Setting Out*]. Within the period stated in the Appendix to Tender, calculated from the Commencement Date, the Contractor shall give notice to the Engineer of any error, fault or other defect found in the Employer's Requirements or these items of reference. After receiving this notice, the Engineer shall determine whether Clause 13 [*Variations and Adjustments*] shall be applied and shall give notice to the Contractor accordingly. If and to the extent that (taking account of cost and time) an experienced contractor exercising due care would have discovered the error, fault or other defect when examining the Site and the Technical Specifications before submitting the Tender, the Time for Completion shall not be extended, and the Contract Price shall not be adjusted."
5.4 Technical Standards and Regulations	*In the first paragraph delete "*the Country's technical standards" *and replace with:* "those technical standards referred to in the Employer's Requirements or where no technical standards are referred to in the Employer's Requirements with accepted International Standards approved by the Employer/the Engineer," *Insert the following at the end of the first paragraph:* "The work shall comply with the latest issue of internationally acceptable standards. The Contractor shall identify the standards he intends to use and shall submit copies of latest editions of relevant standards to the Employer. By definition, such international acceptable standards comprise organizations such as the BIS (Bureau of Indian Standards), ASTM (American Society for Testing and Materials), ISO (International Organization for Standardization), DIN (German Code), BS (British Standards), SS (Swedish Standards), and EN (European Standards). Should the Contractor request alternative to the above standards, other relevant standards may not be used without the Employer's approval. Difference between the standards specified and the proposed alternative standards must be fully described in writing by the Contractor and submitted to the Employer for review and approval. The latest edition of the standards and codes, including amendments thereof, shall be used by the Contractor."
5.5 Trainings	*At the end of Sub-clause 5.5, add:* The Contractor and its Subcontractor shall mandatorily and practically engage the operation and maintenance staff deployed by Employer consisting of personnel at officers and technicians level for erection, testing and commissioning of all the Electro-Mechanical Equipment. The Employer's

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	personnel shall act only and in compliance with the instructions and orders given by the Contractor or its Subcontractors. The contractor shall not be liable for any loss and damage resulting from any non-compliance with the Contractors or its Subcontractors instructions and orders or any actions not covered by such instructions. The Contractor shall provide 22 man-months of training as specified under **Volume-4 [Employer's Requirements]**, with no additional cost to the Employer.
5.6 As-Built Documents	*Insert the following at the end of this Sub-Clause 5.6:* "The Contractor shall supply the Employer with five (5) hard copies and two (2) electronic copies (out of which one electronic copy shall be in source format/software in editable form) of each As-Built Records"
5.8 Design Error	*Delete Sub-Clause 5.8 in its entirety and replace with:* "The Contractor shall be responsible for any errors, omissions, ambiguities, inconsistencies or other defects in the Contractor's Documents or Drawings, and the approval by the Employer or the Engineer of these documents shall not relieve the Contractor in any way from this responsibility. With respect to designs prepared by the Contractor on the basis of Drawings, documents or other information which he receives from the Employer or the Engineer, the responsibilities of the Contractor with respect to the correctness of such Drawings, documents or other information and for notifying the Engineer of any errors, omissions, ambiguities, inconsistencies or other defects therein shall be in accordance with Sub-Clause 1.9 [Errors in the Employer's Requirements]."
Insert new Sub-Clause 5.9 as follows;	
5.9 Warranty by the Contractor	Except as otherwise provided in the Contract, the Contractor: (a) warrants that he did not in any way rely upon: (i) any information, data, representation, statement or document made, or provided to the Contractor, by the Employer, or anyone on behalf of the Employer or any other information, data, representation, statement or document for which the Employer is responsible or may be responsible whether or not obtained from the Employer or anyone on behalf of the Employer; or (ii) the accuracy, adequacy, suitability or completeness of such information, data, representation, statement or document, for the purposes of entering into the Contract; (b) warrants that he enters into the Contract based on his own investigations, interpretations, deductions, information and determinations; and (c) acknowledges that he is aware that the Employer has entered into this Contract relying upon the warranties, acknowledgements and agreements in this Sub-Clause.



6. Staff and Labour	
6.1 Engagement of Staff and Labour	*At the end of Sub-Clause 6.1, add:* "The Contractor is encouraged to the extent possible and reasonable, to employ staff and labour with appropriate qualifications and experience from Bhutan. To the extent possible, the unskilled labour, shall be recruited from Bhutan. The Employer may impose certain restrictions on the Contractors to deploy staff and labour as per the Laws of the Country. The Contractor shall not employ any person who has not completed 18 years of age. The Contractor shall arrange permits for the labour/staff for their entry into Bhutan, at his own cost."
6.3 Persons in the Service of Employer	*At the end of Sub-clause 6.3, add:* *"*Neither the Employer nor the Engineer shall recruit, or attempt to recruit, staff and labour from the amongst the Contractor's personnel working at the Project*"*
6.4 Labour Laws	*Delete Sub-Clause 6.4 and substitute:* "During the subsistence of the Contract, the Contractor and its Subcontractors shall observe, comply and abide at all times with all applicable Laws as applicable to the Contractor's Personnel including all Laws relating to their employment, health, safety, welfare, insurance, gratuity, provident fund, pension, child labour, industrial disputes, contract labour, employment of women etc. The Contractor shall be solely responsible for and shall require and ensure that all the Contractor's Personnel and its Subcontractors and their employees comply with all applicable Laws including labour laws and those concerning safety at Works. The Contractor shall not permit any of the Contractor's Personnel to maintain any temporary or permanent living quarters within the structures forming part of the Permanent Works. The Contractor shall send to the Employer and other authorities as applicable, details of any accident as soon as practicable after its occurrence. The Contractor shall maintain records and make reports concerning health, safety and welfare of persons, and damage to person or property, as the Employer may reasonably require. The Contractor shall keep the Employer, Employer's Personnel and their respective agents, directors, servants and workman indemnified and saved harmless at all times notwithstanding termination of the Contract against and from all demands, actions, claims, proceedings, losses, damages, costs and expenses (including legal fees and expenses) by any Government Instrumentality including any account or in respect of any contravention or failure to observe or comply with any Laws including labour laws. If the Employer or any of the Employer's Personnel are required to pay or reimburse any amount on account of any of the aforesaid or any recovery is made on account thereof by any person, court or Government Instrumentality, the Employer shall have the right to recover the same by deduction from any money due or payable to Contractor including from the Security Deposit. The Employer shall also have right to recover from the

	Contractor any sum required or estimated to be required for making good any loss or damage suffered or incurred by the Employer. The employees of the Contractor and the Subcontractors shall in no event be treated as the employees of the Employer at any point of time. The Contractor shall get all its employees (including employees of Subcontractors) insured with Insurance Companies of Bhutan and comply with Labour and Employment Act of Bhutan 2007 (https://nab.gov.bt/page/acts) from start of work till completion of Works. The Contractor shall have no right to demand payments/claims whatsoever on account of his compliance with its obligations under this Clause including compliance with Laws save and except those specifically mentioned in the Sub-Clause 13.8 of the GCC to the extent as mentioned therein pertaining to Price Adjustment. Without prejudice to the foregoing, the Contractor shall indemnify and keep indemnified and saved harmless the Employer, the Employer's Personnel, and their respective agents, directors, servants and workmen against and from all claims, damage, losses and expenses (including legal fees and expenses) in respect of: *(a) bodily injury, sickness, disease or death, of any person whatsoever including Contractor's Personnel arising out of or in the course of or by reason of the design (where Contractor is responsible), execution and completion of the Works and the remedying of any Defects,* *(b) damage to or loss of any property, real or personal (other than the Works), to the extent that such damage or loss arises out of or in the course of or by reason of the design (where Contractor is responsible), execution and completion of the Works and the remedying of any Defects.* The Contractor shall abide at all times by the Contractor's Labour regulations appended under **Annexure-III of Appendix to Tender**.
6.5 Working Hours	*Delete Sub-Clause 6.5 and substitute:* "Subject to any provision contained in the Contract, the Contractor shall have the option to work continuously by day and by night and on locally recognized holidays or days of rest, without any additional cost to the Employer."
6.7 Health and Safety	*At the end of Sub-Clause 6.7, add:* "The Contractor shall provide and maintain upon the works sufficient, proper and efficient life-saving appliances and first-aid equipment to the approval of the Engineer. The appliances and equipment shall be available for use at all times. The model rules for Health & Sanitary arrangements for Contractor's workmen shall be as specified under **Annexure - IV** of **Appendix to Tender** respectively."
7. Plant, Materials and Workmanship	
7.1 Manner of Execution	*Insert the following paragraphs at the end of this Sub-Clause:*

	"All Materials and Plant that are intended to be or will be incorporated in the Permanent Works shall be new, unless specified otherwise, and shall conform to the Technical Specifications. Such Materials and Plant shall not have been used in Temporary Works or for any other prior purpose whatsoever. Contractor shall warrant that all Materials used by them in carrying out the Works shall be free from defects, of the best quality available and fit for their intended purpose, taking into account local climatic conditions at the Site."
7.4 Testing	*At the end of fifth paragraph, under (b) substitute the words:* "Cost plus reasonable profit" by Cost, which shall be included in the Contract Price."
7.6 Remedial Work	*Under the third paragraph sub clause 7.6 (i), substitute the words:* "Cost plus reasonable profit" by Cost, which shall be included in the Contract Price."
7.7 Ownership of Plants and Materials	*Delete sub para (a) of Sub-Clause 7.7 and substitute by the following:* (a) when it is incorporated in Works.
8. Commencement, Delays and Suspension	
8.1 Commencement of Works	*Delete first sentence of the first paragraph of Sub-Clause 8.1 and substitute:* The Commencement Date shall be reckoned from the date of Signing of Contract Agreement.
8.3 Programme	*Replace 1st line of Sub-Clause 8.3 with the following:* "The Contractor shall submit a detailed work programme to the Engineer within 28 days from the Commencement Date made in the form of critical path method (CPM), the Program Evaluation and Review Technique (PERT) network, using a latest project management software Primavera Professional 6 or Microsoft Project, and showing the sequence in which, it proposes to design, manufacture, transport, assemble, install and pre-commission the facilities. The schedule shall identify the critical path activities and shall have capabilities of predicting completion date of the Works with periodic progress updates during the execution of contract."
8.4 Extension of Time for Completion	*Under Sub-clause 8.4(c), "exceptionally adverse climatic conditions" shall not include rainfall and snowfall.* *Add the following at the end of the Sub-clause 8.4:* "Contractor shall submit application for extension of time with supporting documents within 28 days at the end of each quarter failing which it would be construed that there was no hindrance (even though the hindrance has been brought to the notice of Engineer as per Clause 4.20) during the quarter requiring extension of Time for Completion and Contractor shall forfeit his claim for extension of Time for Completion. In case, hindrances resulting from interface activities with other agencies working at the project are brought to the notice of

	Engineer, the Employer shall determine the duration of such interface activities as per the schedule of interface activities formulated jointly by Contractors and Employer during the course of execution."
8.7 Delay Damages	*At the end of first paragraph of Sub-Clause 8.8, add:* "The Contractor guarantees that it shall attain Completion of the Facilities (or a part for which a separate time for completion is specified in the Contract) within the Time for Completion specified in the Contract pursuant to Sub-Clause 8.2 [*Time for Completion*], or within such extended time to which the Contractor shall be entitled under Sub-Clause 8.5 [*Extension of Time for Completion*] hereof. Delay damages shall be recoverable for delay in completion of interdependent contract milestones and completion of KEM-1 Work milestones as stated in **Annexure-V** to **Appendix to Tender**. Further, the delay damages levied on account of delay in the completion of some Milestones and if, the Contractor achieves the subsequent milestone within specified time, the delay damages already levied forth at item of work shall be refunded. The aggregate amount of such delayed damages shall in no event exceed the ten percent (10%) of the Accepted Contract Amount. Once the "Maximum" is reached, the Employer may consider termination of the Contract, pursuant to Sub-Clause 15.2 [*Termination for Contractor's Default*]. However, the payment of delay damages shall not in any way relieve the Contractor from any of its obligations to complete the Facilities or from any other obligations and liabilities of the Contractor under the Contract. No bonus will be given for earlier Completion of the Facilities or part thereof."
9. Tests on Completion	
9.1 Contractor's Obligations	*Delete first paragraph of Sub-Clause 9.1 and replace with:* "The Contractor shall carry out the Tests on Completion in accordance with this Clause, Sub-Clause 4.9 [*Quality Assurance*] and Sub-Clause 7.4 [*Testing*], after providing the required documents in accordance with the Employer's Requirements, including those referred to in Sub-Clause 5.6 [*As-Built Documents*] and Sub-Clause 5.7 [*Operation and Maintenance Manuals*]." *At the beginning of the third paragraph delete* "Unless otherwise stated in the Particular Conditions" *and replace with:* "The Tests on Completion shall be carried out in the sequence and in accordance with the requirements set out in the Employer's Requirements. Where no sequence is set out in the Employer's Requirements, the Test on Completion shall be carried out in the following sequence": *Insert the following additional Sub-Clause*s after 9.1. (c)



	(d) if required by the Engineer, shall be carried out in the presence of any other person nominated by the Engineer; and (e) shall be coordinated with, or carried out in conjunction with the Contractor(s) of other packages. *Insert the following paragraph between fifth and sixth paragraph*: The duration of the Trail Operation Period shall be 72 hours. The Employer will issue the Operational Acceptance Certificate upon completion of the Trial Operation Period. However, the issuance of Operational Acceptance Certificate shall not constitute the taking-over under Clause 10 *[Employer's Taking Over]*.
	Insert new Sub-clause 9.5 as follows:
9.5 Performance Guarantees	If the Contractor fails to comply with the Performance Guarantees set out in the Bidding Document, the Contractor shall subject to Sub-Clause 2.5 [*Employer's Claims*] pay Performance Damages to the Employer for this default. These Performance Damages shall be calculated in accordance with the details contained in the Schedule of Performance Guarantees in Technical Specification. The Performance Damages shall be over and above any other damages that the Contractor is liable for in accordance with the Contract. These damages shall not relieve the Contractor from his obligation to complete the Works, or from any other duties, obligations or responsibilities which he may have under the Contract. The Contractor acknowledges that the amount of Performance Damages is an agreed and genuine pre-estimate of the loss and damage which the Employer may incur in the event of the Contractor's failure to meet the Guaranteed Performance Levels as set out under Employer's Requirements. The Contractor shall not raise by way of defense or claim, in relation to the Employer's right to deduct Performance Damages, any argument that the amount of performance is a penalty or otherwise unenforceable. If the Contractor's obligation to pay Performance Damages is found for any reason to be void, invalid or otherwise inoperative (other than through the Employer asserting that the performance damages should not be applied) so as to disentitle the Employer from claiming Performance Damages, the Employer shall be entitled to a claim against the Contractor for such damages at Law, resulting from the Contractor's breach of its obligations under the Guaranteed Performance Levels as set out under **Section-7 of Volume-4 [Employer's Requirements]**, provided that the Contractor's liability for such Performance Damages shall not exceed the sum stated under **Section-7 of Volume-4 [Employer's Requirements]**.
10. Employer's Taking Over	
10.2 Taking Over of Parts of the Works	*The phrase "Cost plus reasonable profit" under Sub-Clause 10.2 is substituted by "Cost".*

10.3 Interference with Tests on Completion	*The phrase "Cost plus reasonable profit" under Sub-Clause 10.3 is substituted by "Cost".*
11. Defects Liability	
11.8 Contractor to Search	*The phrase "Cost of the search plus reasonable profit" under Sub-Clause 11.8 is substituted by "Cost of the search".*
Insert new Sub-Clauses 11.12, 11.13 and 11.14 as follows;	
11.12 Latent Defects Liability	At the end of the Defect Notification Period, the Contractor's Liability shall cease except for latent defects and defect liability of spares as specified in Sub-Clause 11.13 [*Defect Liability of Spares*]. The Contractor's liability for latent defects warranty shall be limited to a period of five (5) years from the end of Defect Notification Period. For the purpose of this clause, the latent defects shall be the defects inherently lying within the material or arising out of design deficiency, which do not manifest themselves during the Defect Notification Period, but at a later point of time.
11.13 Defect Liability of Spares	All spares shall be supplied new and defect liability shall be in accordance with the Contract Documents and shall be free from defects in design, engineering, material and workmanship and shall further guarantee as under: a) For five (5) years operational spares (both mandatory and recommended spares): (i) For any item of spares ordered or to be ordered by the Employer for five (5) years operational requirement of the Plant and Equipment which are manufactured as a continuous operation together with the corresponding main equipment/ component, the defects liability period will be 1095 days from the scheduled date of commercial operation of main equipment/plant under the Contract. 'Commercial Operation' shall mean the conditions of operation in which the complete equipment covered under the Contract is officially declared by the Employer to be available for continuous operation at different loads up to and including rated capacity. Such declaration by the Employer, however, shall not relieve or prejudice the Contractor of any of his obligations under the Contract. In case of any failure in the original component/equipment due to faulty designs, materials and workmanship, the corresponding spare parts, if any, supplied will be replaced without any extra cost to the Employer unless a joint examination and analysis by the Employer and the Contractor of such spare parts prove that the defect found in the original part that failed, can safely be assumed not to be present in spare parts. Such replaced spare parts will have the same defect liability as applicable to the replacement made for the defective original part/component provided that such replacement for the original equipment and the spare replaced are again manufactured together. This discarded spare parts will become the property of the

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	Contractor as soon as they have been replaced by the Contractor. (ii) For the item of spares ordered or to be ordered by the Employer for five (5) years operational requirement of the Plant and Equipment, which with the written approval of the Employer, are not manufactured as a continuous operation together with the manufacture of the corresponding main equipment/component, will be warranted for trouble free operation if used within a period of 1095 days (reckoned from the date of delivery at Site). However, if such spare parts are put to use after 1095 days of the delivery at Site then the guarantee of such spares will stand valid till the expiry of 730 days from the date of issue of Test on Completion Certificate of equipment/plant for trouble free operation after such spares are put in service. (iii) For long term requirement of spares that may be ordered by the Employer to cover requirements beyond five (5) years of initial operation of plants, the warranty period will be 730 days from the date they are put into trouble free operation if used within a period of 730 days from the delivery at Site. b) The defect liability of spares that are not used within 24 months from the respective dates of the delivery at Site covered in para (ii) and (iii) above, will however be subject to condition that all such spares being stored/maintained/preserved in accordance with Contractor's standard recommended practice, if any, and the same has been furnished to the Employer. c) To enable the Employer to finalize the requirement of recommended spare which are to be ordered subsequent to placement of order for main Plant and Equipment, in addition to necessary technical details, catalogue and such other information brought-out herein above, the Contractor will also provide a justification in support of reasonableness of the quoted prices of spares which will, inter-alia, include documentary evidence that the prices quoted by the Contractor to the Employer are not higher than those charged by him from other customers in the same period. d) In addition to the spares recommended by the Contractor, if the Employer further identifies certain particular items of spares, the Contractor will submit the competitive prices and delivery quotation for such spares within 30 days of receipt of such request with a validity period of 6 months for consideration by the Employer and placement of order for additional spares if the Employer so desires. e) The Contractor shall guarantee the long-term availability of spares to the Employer for the full life of the equipment covered under the Contract. The Contractor shall guarantee that before going out of production of spare parts of the equipment covered under the Contract, he shall give the Employer at least 2 years advance notice so that the latter may order his bulk requirement of spares if it so desires. The same provision will also be applicable to Subcontractors. Further, in case of discontinuance of manufacture of any spares by the Contractor and/or his Subcontractors, the Contractor will provide the Employer, 6

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	months in advance, with full non-proprietary manufacturing drawings, material specifications and technical information including information on alternative equipment makes required by the Employer for propose of manufacture/procurement of such items. f) The price of all future requirements of items of spares beyond 3 years operational requirement will be derived from the corresponding ex-works price at which the order for such spares have been placed by Employer as a part of mandatory spare parts or recommended spares. Ex-works order price of future spares shall be computed in accordance with the price adjustment provisions covered under the main Contract with the base indices mentioned therein and there will be no ceiling on the amount of variation in the prices. The above option for procuring future recommended spares by the Employer shall remain valid for the period of 5 (five) years from the date of issue of Test on Completion Certificate of the equipment. g) The Contractor will indicate in advance the delivery period of the items of spares, which the Employer may procure in accordance with above Sub-clause. In case of emergency requirements of spares, the Contractor would make every effort to expedite the manufacture and delivery of such spares on the basis of mutually agreed time schedule. h) In case the Contractor fails to supply the mandatory spare parts, recommended or long-term spares in the terms stipulated above, for reasons attributable to the Contractor, the Employer shall be entitled to purchase the same from the alternate sources at the risk and the cost of the Contractor and recover from the Contractor, the excess amount paid by the Employer over the rates worked on the above basis. In the event of such risk purchase by the Employer, the purchase will be as per the Works and Procurement Policy of the Employer prevalent at the time of such purchases and the Employer at his option may include a representative from the Contractor in finalizing the purchases. i) It is expressly understood that the final settlement between the Parties in terms of relevant clauses of the Contract shall not relieve the Contractor of any of his obligations under the provision of long-term availability of spares and such provisions shall continue to be enforced till the expiry of 5 years period reckoned from the date of issue of Test on Completion Certificate of the Plant/Equipment unless otherwise discharged expressly in writing by the Employer. Further, the provisions pertaining to long-term availability of spares shall be extended beyond 5 years applicability period mentioned herein above if so desired by the Employer up to 15 years and at the mutually acceptable escalation formula.
11.14 Warranty and Liability of Software	Subject to the defect notification period, the Contractor's warranty and liability for its own software included in the Facilities shall be limited solely to the elimination of reproducible errors and malfunction thereof, provided the software is installed on hardware supplied or authorized by the contractor. The contractor shall be granted sufficient access by the employer with all documentation and information to trace the error. Instead of eliminating errors in

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	the supplied version of software, the contractor shall have the right to establish an error free later version and supply the same at no additional cost to the Employer. The newer version so implemented shall be compatible with the existing hardware supplied or authorized by the Contractor. With respect to standard software (e.g. UNIX, DOS, Words, Excel etc.,) licensed from others, the Contractor's warranty and liability shall be limited solely to the warranties and liabilities by the licenses of such software.
12. Tests after Completion	
12.1 Procedure for Tests after Completion	*Delete sub-paragraph (a) and replace with:* "(a) The Contractor shall be responsible for the provision of all electricity, fuel and materials for the tests, at his own cost." *Delete Sub-clause (b) and replace with:* "(b) The Contractor shall provide adequately qualified personnel, sufficient supply of all raw materials, utilities, lubricants, chemicals, catalysts and other materials as required, together with all necessary plant and equipment; and shall perform all the works and services of whatsoever nature required to properly carry out the Tests and Commissioning."
12.2 Delayed Tests	*The phrase "Cost plus reasonable profit" at the end of 1st para of this Sub-Clause 12.2 be substituted by "Cost".*
12.4 Failure to Pass Tests after Completion	*The phrase "Cost plus reasonable profit" at the end of this Sub-Clause is substituted by "Cost".*
13. Variations and Adjustments	
13.1 Right to Vary	*Replace second sentence of this sub clause as under:* "Other than as stated under Sub-clause 11.4 [*Failure to Remedy Defects*] and in the event of a variation omitting part of the Works, the Contractor shall have no claim against the Employer (including claim for profit) except in relation to those Costs already incurred by the Contractor in anticipation of carrying out that part of the Works" *Insert the following paragraph at the end of this Sub-clause* "However, any works identified by the Employer as being necessary to amend the Contractor's Design to make the Works fit for the purposes intended, as described in the Employer's Requirements, shall not be considered a Variation."
13.2 Value Engineering	*Add the following after Sub-Clause 13.2* "Similarly, Employer may, at any time, ask the Contractor to study and evaluate a proposal suggested by the Employer, which (in the Employer's opinion) will, if adopted, (i) accelerate completion, (ii) reduce the cost to the Employer for executing, maintaining or operating the Works, (iii) improve the efficiency or value to the Employer of the completed Works, or (iv) otherwise be of benefit to the Employer without resulting in reductions in quality, anticipated life or operational efficiencies. The Contractor shall study and evaluate at its own cost and respond to the proposal from Employer in writing within 28 (Twenty-Eight)

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	days regarding the suitability of the proposal. If such a proposal as suggested by the Employer and is agreed by the Contractor, the proposal shall be prepared at the cost of the Contractor and shall include the items listed in Sub-Clause 13.3 [*Variation Procedure*].” Both parties (Employer and Contractor) shall also agree for adjustment in the Contract Price, if any, resulting from the change. The overall responsibilities, safety and suitability of the Works shall be of the contractor, if such proposal as requested by the Employer is agreed by the Contractor.”
13.3 Variation Procedure	*Insert the following paragraph at the end of this Sub-clause* “Where the Employer has instructed a Variation, if the Employer and Contractor are unable to agree upon the valuation of the work which is the subject of the Variation, the Engineer shall determine the valuation of the Variation in accordance with Sub-Clause 3.5 [*Determinations*] and as follows: (i) if the Pricing Schedule prescribes specific rates or prices to be applied in determining the valuation, the rates or prices will be used; (ii) if Sub-Clause 13.3(i) does not apply, the rates or prices set out in the Pricing Schedule will be applied to the extent that the Engineer determines it is reasonable to apply them; (iii) to the extent that neither Sub-Clause 13.3 (i) or (ii) apply, a reasonable amount determined by the Engineer; having regard to the cost of material, actual wages of labour, and ownership and operation cost of construction equipment required as per standard norms or if standard norms are not specified/ available then on the basis of labour/ material/ construction equipment actually engaged for particular work. Over and above the cost of labour, material arranged by contractor ownership and operation cost of construction equipment and other direct related cost, an element of 10% shall be allowed to cover the contractor’s supervision charges. (iv) in determining the deduction to be made for scope which is taken out of the Contract, or for a Variation which results in a saving to Contractor, the deduction will include an amount for overhead and profit; and (v) the Employer's valuation of the Variation under Sub-Clause 13.3(iii) and (iv) shall include an amount equal to five percent (5%) for overheads and five percent (5%) for profit. At the Employer's request, the Contractor shall provide priced copies of vendor and/or subcontractor quotations, in relation to the costs of any Plant, Materials, labour, equipment not previously set out in or covered by the rates and prices in the Pricing Schedule and which form the basis of the Contractor's proposal for adjustment to the Contract Price in accordance with Sub-Clause 13.3(iii).”
13.5 Provisional Sums	*Sub-Clause 13.5 is not applicable*
13.6 Daywork	*Sub-Clause 13.6 is not applicable*

13.7 Adjustments for Changes in Legislations	*At the end of Sub-Clause 13.7, add:* "Notwithstanding the foregoing, such additional or reduced cost shall not be separately paid or credited if the same shall already have taken into account in the indexing or any inputs to the Price Adjustment Formulae in accordance with the provisions of Sub-Clause 13.8. Provided always that any variations resulting from the changes in legislation, in respect of wages of the labour and staff of the Contractor, shall be deemed to be included in the Adjustment for Changes in Cost (price adjustment formula) included in Sub-Clause 13.8 hereof and shall not be paid separately by the Employer under this Sub-Clause 13.7. Any variation in power tariff as may be applicable during execution of works shall be borne by the Contractor and shall not be paid by the Employer separately under this Sub-Clause 13.7."
13.8 Adjustments for Changes in Cost	*Delete Sub-Clause 13.7 and substitute:* "The amounts payable to the Contractor shall be adjusted for rise or fall in the cost of labour, goods and other inputs to the Works, by the addition or deduction of the amounts determined by the formulae prescribed in this Sub-Clause. To the extent that full compensation for any rise or fall in Costs is not covered by the provisions of this or other Clauses, the Accepted Contract Amount shall be deemed to have included amounts to cover the contingency of other rises and falls in costs. Subject to the conditions laid down hereunder, Contract Price is subject to price adjustment in accordance with the Price Adjustment formulae incorporated in this clause. However, if the Contractor fails to complete whole of the Works within the Time for Completion prescribed under Clause 8.2, adjustment of prices thereafter until the date of completion of the Works shall be made using either (i) the indices or prices applicable on the date 49 days prior to the expiry of the Time for Completion, or (ii) the current indices or prices; whichever is more favourable to the Employer. No price variation shall be admissible for: a) An amount of 15% (Fifteen percent) of the Accepted Contract Amount which shall be fixed element. b) The advance payment up to the point the advance was released under Sub-Clause 14.2. c) Any items valued at current prices. Payment to Contractor for work done shall be adjusted for increase or decrease in the cost of labour and materials according to the procedure mentioned hereafter. The price adjustment provisions under this clause shall be applicable to the price breakup furnished by the Contractor and applicable only for the work that is carried out within the Time for Completion and for authorized extended time.

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The Price adjustment formula is as given below:

I. Supply of Electro-Mechanical Equipment

a) For supply of Electrical Equipment

$$P_v = P_0 \left[0.15 + 0.35 \frac{S_n}{S_0} + 0.15 \frac{C_n}{C_0} + 0.35 \frac{L_n}{L_0} \right] - P_0$$

b) For supply of Mechanical Equipment

$$P_v = P_0 \left[0.15 + 0.50 \frac{S_n}{S_0} + 0.35 \frac{L_n}{L_0} \right] - P_0$$

Where,

P_v = Price adjustment amount payable

P_0 = Adjusted value of supply till project site (minus advance payment)

A = 15%, as fixed component, which is not subject to any price adjustment

S_0 = Steel price index 28 days prior to bid submission from the country of origin.

S_n = Monthly average steel price indices from the country of origin one month prior to date of Invoice.

C_0 = Copper price index 28 days prior to bid submission from the country of origin.

C_n = Monthly average copper price indices from the country of origin one month prior to date of Invoice.

L_o = Labour price index 28 days prior to bid submission from the country of origin.

L_n = Labour Price index from the country of origin one month prior to date of Invoice.

The percentage of components for compensation due to variation in labour, steel and copper are as defined below**:**

Description	**A**	**P_S**	**P_C**	**P_L**
For Electrical Equipment	15	35	15	35
For Mechanical Equipment	15	50	-	35

II. Supply of Generator Transformer

The IEEMA Formula for "Price Variation Clause for Power Transformers and Reactors complete with all accessories and components of ratings above 10MVA or voltage above 33kV upto 400kV supplied against export/deemed export contracts against duty free inputs under special imprest licensing scheme" published dated April 01, 2015, shall be adopted. The base date for indices shall be in conformity with the Bidding Document.

<u>Indices - For Supply from Bhutan and India</u>

L = All India Consumer Price Index for Industrial Workers,

Base (2016=100) as published by Labour Bureau, Ministry of Labour & Employment, Government of India.

S = Wholesale Price Index for Manufacture of Basic Metals, Mild Steel - Flat Products, Base (2011-12=100), as issued by Office of Economic Advisor, MoCI, India.

C = Wholesale Price Index for Manufacture of Non-Ferrous Metals including Precious Metals, Copper Shapes - bars/rods/flats, Base (2011-12=100), as issued by Office of Economic Advisor, MoCI, India.

M = Wholesale Price Index for All Commodities, Base (2011-12=100), as issued by Office of Economic Advisor, MoCI, India.

Indices - For Supply from Country other than Bhutan and India

For supply off-shore supply, the indices of the respective country of origin shall be applicable. The Bidder should submit the indices to the Employer.

III. Erection, Testing and Commissioning

The adjustment in respect of changes in cost or services shall be determined from the following formula:

$$P_v = P_0 \left[0.15 + 0.60\frac{L_n}{L_0} + 0.15\frac{F_n}{F_0} + 0.10\frac{E_n}{E_0} \right] - P_0$$

Where,

P_v = Price adjustment amount payable

P_0 = Cost of Complete Erection, Testing, Commissioning and other Services.

A = 15%, as fixed component, not subject to any price adjustment

L = All India Consumer Price Index for Industrial Workers, Base (2016=100) as published by Labour Bureau, Ministry of Labour & Employment, Government of India.

F = Retail Price of HSD at Doksum outlet which is inclusive of taxes and duties per litre of HSD.

E = Wholesale Price Index of Manufacture of Metal-forming Machinery and Machine Tools Base (2011-2012 = 100) as issued by Office of Economic Advisor, MoCI, Government of India.

The weightings shall be those listed in the **Annexure-VI of Appendix to Tender**.

Base, Current and Provisional Indices

The base date shall be twenty-eight (28) days prior to the date of submission of bids. The current indices or prices shall be those prevailing one month prior to the last day of the period to which a particular Interim Payment Certificate is related.

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	Payment of price adjustment will be made to the Contractor along with the Interim Payments for the works performed to which price adjustment amount belongs. If at any time the current indices are not available, provisional indices as determined by the Engineer will be used, subject to subsequent correction of the amounts paid to the Contractor when the current indices become available. In case Government of India, stops publishing any of the price indices at any time and announces a new series with a linking factor for conversion of index of new series to the old series, regulation of price variation will be done using the indices of new series along with linking factor from the period the indices of old series become unavailable. However, if the new series released by the relevant source does not have the linking factor the new series shall be used without use of Linking Factor and current as well as base indices of new series shall be used from the date, indices of old series becomes unavailable. Items of works for which rates have been derived from Price Schedules and analogous items in the Price Schedules shall be eligible for Price Adjustment as per the Price Adjustment formula with base date as per the contract. The maximum amount of price adjustment payable shall be up to twenty percent (20%) of the Accepted Contract. **Other Changes in Cost** To the extent that full compensation for any rise or fall in costs to the Contractor is not covered by the provisions of this or other Articles in the Contract, the unit rates and prices included in the Contract shall be deemed to include such difference.
14. Contract Price and Payment	
14.1 The Contract Price	*After subparagraph (d) in Sub-Clause 14.1, add the following:* All Goods imported by the Contractor into the Country for direct use for the Works of Project shall be exempted from customs & other import duties and taxes, with Employer's prior written approval obtained for import. The Employer shall endorse the necessary exemption documents prepared by the Contractor for presentation in order to clear the Goods through customs. Similarly, all Goods and materials procured within the Country for direct use for the Works of the Project shall be exempted from taxes imposed within the country. If exemption is not granted, the customs duties and Bhutan Sales Tax payable and paid by the Contractor in the Country shall be reimbursed by the Employer. All Contractors' equipment shall be re-exported on completion of the Contract. If not re-exported, the Goods will be assessed for duties applicable to the Goods involved in accordance with the Laws of the Country. However, exemption may not be available for



	i) Goods which are similar to those locally produced, unless they are not available in sufficient quantities or are of a different standard to that which is necessary for the works; ii) Goods which are of personnel use for the Contractor's staff and labourers; and iii) any element of duty or tax inherent in the price of goods or services procured in the country, which shall be deemed to be included in the Contract Price. The Bid Price shall include all Custom and other duties, levies, taxes, etc. outside the Employer's Country. The Contractor's staff and personnel will be liable to pay personal income tax in the Country in respect of such of their salaries and wages as are chargeable under the laws and regulations in force in the Country, and the Contractor shall perform such duties in regard to such deductions thereof as may be imposed on him by such laws and regulations. The Tax Guidelines as applicable for the project have been detailed under **Annexure-VII of Appendix to Tender**. The Royal Government of Bhutan shall receive from the Contractor royalty for timber, boulders, and aggregate and other construction materials required from the Country for the Project. The schedule of royalty for different materials can be obtained from the relevant agencies.
14.2 Advance Payment	*Delete Sub-Clause 14.2 and substitute:* Advance for mobilization and design shall be interest free. The Advance shall be made against Bank Guarantee in the form and manner prescribed by the Employer. The Employer shall pay, if opted for by the Contractor, advance exclusively for the costs of mobilization and design in an amount equal to the advance payment as stated in the Contract Data. The Engineer shall issue an Interim Payment Certificate for the advance payment after receiving a Statement (under Sub-Clause 14.3 [*Application for Interim Payment Certificates*] and after the Employer receives: (i) Performance Security in accordance with the Sub-Clause 4.2 [*Performance Security*]; and (ii) a bank guarantee in the amounts and currencies equal to the advance payment. Recovery of advance for mobilization and design shall commence in the next Interim Payment Certificate following that in which the total of all gross value of Interim Payment Certificates has reached 10% of the Accepted Contract Amount and the recovery of the total amount of such advance shall be done on pro-rata basis and shall be completed by the time the gross value of Interim Payment Certificates has reached 80% of the Accepted Contract Amount. The Contractor shall always have the option to have the recoveries commenced and/or completed earlier, and/or to have recoveries effected in installments of higher amounts and also to repay part or

	whole of the advance by direct payment rather than through running payment. The advances specified here-in-above may be released at any time during pendency of Contract subject to fulfillment of the above stipulated conditions and further provided that the Engineer is fully satisfied that the advance payments so released shall be completely recovered prior to the time when 80 percent of the Accepted Contract Amount has been certified.
14.4 Schedules of Payments	*Delete last paragraph of Sub-Clause and add the following:* The Employer shall pay the Contractor in the following manner and time, on the basis of the Price Breakdown given in section of Price Schedules. Payment will be made in the currencies quoted by the bidder unless otherwise agreed between the parties. Applications for payment in respect of part deliveries may be made on pro-rata basis as work proceeds in accordance with the Terms and Procedures as defined herein. **A. Terms of Payment and Procedure** **i) Plant and Equipment Supplied from Country other than Bhutan and India** In respect of plant and equipment supplied from abroad, the following payments shall be made: ▪ **Ten percent (10%)** of the total CIF/CIP amount as an advance payment against receipt of invoice and an irrevocable advance payment security for the equivalent amount made out in favor of the Employer. The advance payment security may be reduced in proportion to the value of the plant and equipment shipped FOB or delivered to the site, as evidenced by shipping and delivery documents. ▪ **Forty percent (40%)** of the total or pro rata CIF/ CIP amount upon Incoterm "FOB" or "FCA," within 45 days after receipt of invoice and shipping documents duly endorsed by the Employer. ▪ **Forty percent (40%)** of the total or pro rata CIF/ CIP amount upon Incoterm "CIP" till Project Site, within 45 days after receipt of invoice supported with Goods Receipt Note (GRN) duly signed by Project Manager/ Engineer-in-Charge. ▪ **Five percent (5%)** of the total or pro rata (generating unit wise) CIF/CIP amount upon issue of the Operational Acceptance Certificate, within 45 days after receipt of invoice. ▪ **Five percent (5%)** of the total or pro rata (generating unit wise) CIF/CIP amount upon issue of the, Taking over Certificate within 45 days after receipt of invoice. **ii) Plant and Equipment Supplied from Bhutan and India** In respect of plant and equipment supplied from Bhutan and India, the following payments shall be made: ▪ **Ten percent (10%)** of the total CIP amount as an advance payment against receipt of invoice, and an irrevocable advance payment security for the equivalent amount made out in favor

of the Employer. The advance payment security may be reduced in proportion to the value of the plant and equipment delivered to the site, as evidenced by shipping and delivery documents.

- **Forty percent (40%)** of the total or pro rata CIP amount upon Incoterm "Ex-Works," upon delivery to the site within 45 days after receipt of invoice.
- **Forty percent (40%)** of the total or pro rata CIP amount upon Incoterm "CIP" till Project Site, within 45 days after receipt of invoice supported with Goods Receipt Note (GRN) duly signed/ endorsed by Project Manager/ Engineer-in-Charge.
- **Five percent (5%)** of the total or pro rata CIP amount upon issue of the Operational Acceptance Certificate, within 45 days after receipt of invoice.
- **Five percent (5%)** of the total or pro rata CIP amount upon issue of the, Taking over Certificate within 45 days after receipt of invoice.

iii) Installation and other Services

In respect of installation services for both the foreign and local currency portions, the following payments shall be made:

- **Ten percent (10%)** of the total installation and other services amount as an advance payment against receipt of invoice and an irrevocable advance payment security for the equivalent amount made out in favor of the Employer. The advance payment security may be reduced in proportion to the value of work performed by the Contractor as evidenced by the invoices for installation services.
- **Eighty percent (80%)** of the measured value of work performed by the Contractor, as identified in the said Work Program, during the preceding month, as evidenced by the Employer's authorization of the Contractor's application, will be made monthly within 45 days after receipt of invoice.
- **Five percent (5%)** of the total or pro rata value of installation services performed by the Contractor as evidenced by the Employer's authorization of the Contractor's monthly applications, upon issue of the Operational Acceptance Certificate, within 45 days after receipt of invoice.
- **Five percent (5%)** of the total or pro rata value of installation services performed by the Contractor as evidenced by the Employer's authorization of the Contractor's monthly applications, upon issue of the, Taking over Certificate within 45 days after receipt of invoice.

B. Payment Procedures

The procedures to be followed in applying for certification and making payments shall be as follows:

In accordance with the provisions of GCC Clause 14 *[Contract Price and Payment]*, the Employer shall pay the Contractor in the following manner and at the following times, on the basis of the

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Price Break down given in the section on Price Schedules. Payments will be made in the currencies quoted by the Bidder unless otherwise agreed between the parties. Application for payment in respect of part deliveries made by the Contractor shall be made on pro-rata basis as work proceeds in accordance with the Terms and Procedures as defined herein in this Appendix.

Note

i) All the Payments shall be made by the Employer through Telegraphic Transfer or DD or cheque in favor of Contractor (defined in the Contract Agreement) as per mutually agreed terms between the Parties to the comfort level of Employer. Also, where are to be effected through Letter of Credit (LC) the same shall be subject to the latest Uniform Customs and Practice for Documentary Credit, of the International Chamber of Commerce. The LC charges shall be borne by the Contractor.

ii) The LC will be irrevocable and will be confirmed at Contractor(s) cost if requested specifically by the Contractor.

iii) If LC is required to be extended/ reinstated for reasons not attributable to the Employer, the charges there off shall be to the Contractor's account.

i) Goods Supplied from Country other than Bhutan and India

The following documents shall be furnished for goods supplied from country other than India and Bhutan.

a) Within 24 hours of shipment, the Contractor shall notify the Employer, and the insurance company by cable or telex or fax the full details of the shipment including contract number description of goods, quantity, the vessel, the bill of lading number and date, port of loading, date of shipment, port of discharge etc. The Contractor shall mail the following documents to the Employer, with a copy to the insurance company.

b) 4 copies of Contractor's invoice showing goods description, quantity, unit price, total amount.

c) Original and 4 copies of the negotiable, clean, on-board bill of lading marked freight prepaid and 4 copies of nonnegotiable bill of lading.

d) 4 copies of packing list identifying contents of each package.

e) Insurance certificate.

f) Contractor's guarantee certificate.

g) Inspection certificate, issued by the nominated inspection agency/ Employer and the Contractor's factory inspection report.

h) Certificate of approval of Test report issued by the Employer and Dispatch clearance issued by the Employer.

i) Certificate of confirmation of makes of equipment as agreed between Employer and the Contractor, and

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	j) 4 copies of Certificate of origin. The above documents shall be received by the purchaser at least one week before arrival of goods at the port or place of arrival and if not received, the Contractor will be responsible for any consequent expenses. **ii) Goods supplied from Bhutan and India** The following documents shall be furnished for goods supplied from Bhutan and India: a) Within 24 hours upon delivery of goods to the transporter, the Contractor's shall notify the purchaser and their representative at site, and insurance company by cable/ telex/ fax the full details of the dispatch including contract number, description of the goods, quantity, wagon number, railway receipt number and date and name of the consignee etc. The Contractor shall mail the following documents to the Employer with a copy to the insurance company. b) 4 (four) copies of the Contractor's invoice showing goods description, quantity and price, total amount. c) Lorry Receipt (consignment note)/ railway receipt/ acknowledgment of receipt of goods from the Contractor. d) Contractor's guarantee certificate. e) Insurance certificate. f) 4 (four) copies of packing list identifying contents of each package. g) Inspection certificate issued by the nominated inspection agency and the supplier's factory inspection report. h) Certificate of approval of Test Reports issued by the Employer and Dispatch Clearance issued by the Employer. i) Certificate of confirmation of makes of equipment as agreed between employer and the Contractor and, j) 4 (four) copies of certificate of origin. k) Any other certificates as mutually agreed between Employer and the Contractor. The above documents shall be received by the Employer and their representative at site before arrival of the goods (except where the goods have been delivered directly to the consignee with all documents) and if, not received the Contractor will be responsible for any consequent expenses.
	Add New Sub-Clause 14.5.1
14.5.1Materials	"The Contractor shall at his own expense provide/arrange all Materials required for the bonafide use in the Works under the Contract. The Engineer or his representative shall be entitled at any time to inspect and examine any materials intended to be used in the Works, either on the Site or at factory or workshop or other place(s) where such materials are assembled, fabricated, manufactured, or at any place where these are placed or from where these are being

	obtained. For this purpose, the Contractor shall afford such facilities as may be required for such inspection. (A) The Engineer shall during the progress of the Works have power to order in writing from time to time in respect of following: (i) removal from the Site, within such time or times as may be specified in the order, of any materials which in the opinion of the Engineer, are not in accordance with the Contract; (ii) substitution of proper and suitable materials; and (iii) removal and proper re-execution, notwithstanding any previous test thereof or interim payment therefore, of any work which in respect of materials or workmanship is not, in the opinion of the Engineer, in accordance with the Contract. (B) In case of default on the part of the Contractor in carrying out such order, the Employer shall be entitled to employ and pay other persons to carry out the same and all expenses consequent thereon or incidental thereto shall be recoverable from the Contractor by the Employer, or may be deducted by the Employer from any monies due or which may become due to the Contractor or from the bank guarantee provided by the Contractor under this Contract, or otherwise. The Engineer shall have full powers for removal of any or all materials brought to Site by the Contractor, which are not in accordance with the Contract specifications or samples, approved by him. Should the Contractor fail to remove the rejected materials, the Engineer shall be at liberty to have them removed by other means at the Contractor's cost. The Employer shall have full power to procure other proper materials to be substituted at Contractor's costs."
14.6 Issue of Interim Payment Certificates	*At the end of first sentence of Sub-Clause 14.6, add:* "and the Contractor has submitted the proof of payment of insurance premium as per the requirement of the Contract and has submitted detailed programme in accordance with Sub-Clause 8.3 *[Programme]* of the Contract."
14.7 Payment	*Delete sub paragraph (b) of Sub-Clause 14.7 and substitute:* "(b) Application for Interim Payment Certificate submitted by the Contractor shall be paid within 28 days of the submission as verified by the Engineer. If there is delay in release of undisputed payment beyond 56 days, then interest at rate specified in the Appendix to Tender shall be calculated on the payable amount after due recoveries from the 57th day onward till the date of actual payment." *In sub paragraph (c) of Sub-Clause 14.7: delete "56" and substitute with "112".* *At the end of the Sub-Clause, insert the following paragraph:*

	The Employer intends that funds released for the project as advance or against the work done is utilized for the project itself and Contractor does not divert project funds for other businesses. The Contractor shall provide a detailed month-wise cash flow estimate at the beginning of each financial year duly revised at quarterly intervals, if required so by the Employer. The submission to and consent by the Employer of such programmes or the provision of such general descriptions or cash flow estimates shall not relieve the Contractor of any of his duties or responsibilities under the Contract. All payments to be made by the Employer to the Contractor (advance, Interim Certificate Payments and Final Bill) shall be released and credited into a designated Escrow Account with the following conditions: The designated Escrow Account shall be opened by the Contractor after Notification of Award with Nationalized/Scheduled Commercial Bank in Bhutan. Particulars of the Escrow Account shall be submitted by the Contractor with the Employer before submitting request for mobilization advance. The Employer will release payments in the Escrow Accounts only. During the currency of the contract, Contractor may become subject to any scheme of Corporate Debt Restructuring or any other scheme of debt restructuring (DR Scheme). Since the Escrow Account involves an independent tripartite agreement between the Bank, Employer and the Contractor, the Escrow Account/Agreement shall have an overriding effect over the terms and conditions of the DR Scheme. The Escrow Account/Agreement shall not be affected by the terms and conditions of DR Scheme and the Contractor shall be required to disclose this condition to the DR Authority while submitting the case under DR Scheme. In case of financial crunch or other exigency, the Employer may make direct payment to the vendor in the interest of the project with the consent of the Contractor.
14.8 Delayed Payment	*Sub-Clause 14.8 is replaced with the following:* "Omissions on the part of the Engineer to pay the amount due upon measurement or otherwise shall neither vitiate nor make the contract void. Further, no claim for interest or damages will be entertained or payable by the Employer upon i) any Bank Guarantee or ii) payments in arrears or iii) any balance which may become due on final settlement / re-conciliation of the account or iv) payments withheld by the Employer owing to any dispute or difference between the parties. Save as above, interest on delayed payments shall be regulated as per Sub-Clause 14.7 [*Payment*]."
14.9 Release of Retention Money	*At the beginning of Sub-Clause 14.9, insert:*

	"The Contractor may substitute the Retention Money with a bank guarantee in the form, and from a source, acceptable to the Employer valid till 90 days beyond Defects Notification Period. However, the amount of substitution of retention money with a Bank Guarantee shall not be less than Nu. 50.0 million. A Bank Guarantee either issued by a bank/financial institution in Bhutan or any nationalized/scheduled bank in India with endorsement/ counter guarantee by a bank/financial institution in Bhutan shall only be acceptable. The Employer shall return the Retention Money/ Bank Guarantee (which had replaced the Retention Money) to the Contractor within 28 days after issue of Taking Over Certificate in terms of GCC 10.1 [*Taking over of the Works and Sections*]
14.10 Statement at Completion	*Delete paragraph (c) of Sub-Clause 14.10*
14.15 Currencies of Payment	*Delete the phrase "Sub-Clause 13.5[Provisional Sums] and "under Sub-Clause 14.15(a)(ii).*
15. Termination by Employer	
15.2 Termination by Employer	*At the end of Sub-Clause 15.2 add the following clause:* "The Employer shall terminate any defaulting Subcontractors and forfeit 5% additional Performance Security furnish by them. In case of such termination, the main contractor subject to approval of the Employer shall field/appoint new Subcontractor for the execution and successful completion of the specified work packages. Such new Subcontractor shall also furnish 5% additional performance security applicable for both supply and service components valid till the Defect Notification Period".
16. Suspension and Termination by Contractor	
16.1 Contractor's Entitlement to Suspend Work	*"21 days" appearing in 1st paragraph of Sub-Clause 16.1 be replaced by "56 days"* *The phrase "Cost plus reasonable profit" under Sub-clause 16.1* is deleted and substituted by *"Cost,* which shall be included in the Contract Price".
16.2 Termination by Contractor	*Delete subparagraph 16.2.1(a) of Sub-Clause 16.2.1* *"14 days" time period appearing under Sub-Clause 16.2 be replaced by "42 days".*
16.3 Cessation of Work and Removal of Contractor's Equipment	*In sub-para (b) between "received" and "payment" insert:* *"or is entitled to receive"* *At the end of sub-paragraph (b) delete* "and" *and at the end of sub-paragraph (c) delete the full stop and replace with comma.* *Insert the following sub-paragraphs (d) and (e) as follows:* (d) to the extend legally possible, procure the assignment or novation or otherwise to the Employer or an entity nominated by the Employer, all rights, title and benefit of the Contractor to the Works and in the Plant, Materials and other work as at the date of termination; and

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	(e) remove from the Site any wreckage, rubbish and debris of any kind and leave the whole of the Site in a clean and safe condition.
18. Insurance	
18.2 Insurance for Works and Contractor's Equipment	*Delete first sentence of Sub-Clause 18.2 and substitute:* The insuring Party shall insure the Works (EAR), Plants, Materials and Contractor's Documents and other policies as may be required) for not less than 125% of Accepted Contract Amount in the joint name with Employer as principal insured. The policies are to be reviewed periodically to maintain them at not less than full replacement cost. In addition to above, policy(ies) shall cover cost of demolition, removal of debris, professional fees, and escalation. Insurance policy shall have an express provision to the effect that the insurer shall necessarily obtain prior 'no objection' certificate from the Engineer before payment of insurance claim under the insurance policy. *Delete last paragraph of Sub-Clause 18.2* *At the end of Sub-Clause 18.2,add:* If the Contractor receives instructions from the Employer to insure against any risk listed in sub para (a) to (h) listed in Sub-Clause 17.3 *[Employer's Risks]*, such insurance if available shall be affected, at the cost of the Employer, with an Insurance Company acceptable to the Employer and shall be in the joint names of the Contractor and the Employer. The insurance policies required under the Contract shall be availed by the Contractor from the insurance companies registered under laws of Bhutan.
Insert new Sub-Clause 18.5 as follows	
18.5 Insurance for Design	The Contractor shall effect the professional indemnity insurance, which shall cover the risk of professional negligence in the design of the Works. This insurance shall be for a limit of not less than 125% of the Accepted Contract Amount. The Contractor shall use his best endeavours to maintain the professional indemnity insurance in full force and effect until the issue of Performance Certificate by the Employer under GCC Sub-Clause 11.9 *[Performance Certificate]*.
19. Force Majeure	
19.4 Consequences of Force Majeure	*Under sub-para (b) of Sub-Clause 19.4, delete "payment of any such Cost" and substitute with "payment of 75% of such Cost".*
20. Claims, Disputes and Arbitration	
20.1 Contractor's Claims	*Under 6th para of Sub-Clause 20.1, delete "42 days" and substitute with "90 days".* *At the end of Sub-Clause 20.1, add the following:* "Further, the resources (Equipment/ Manpower) shown in the Data Sheet are solely the Contractor's estimate and the Contractor has committed to deploy the resources indicated to complete the Works within the Time for Completion. No claims will be entertained on

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	the grounds that there has been less progress than anticipated using these resources. The causes or hindrances would have to be established by the Contractor independently. By making these Data Sheets a part of the Contract does not absolve the Contractor from the responsibility of deploying additional resources to complete the Works within Time for Completion. No payments would be made towards the expenses incurred on deploying the additional resources as such unless expressly agreed by the Employer in writing."
21. Disputes and Arbitration	
20.4 Obtaining Dispute Adjudication Board's Decision	*At the end of Sub-Clause 20.4, add:* "The decision of DAB shall be final and binding on the parties for all the cost claims up to and inclusive of Nu. 50.00 Million and such decision of DAB shall not be subject to Arbitration."
20.6 Arbitration	*The Sub-Clause 20.6 is replaced with the following:* "Subject to Sub-Clause 20.4 & 20.5 of these Conditions, unless settled amicably, any dispute in respect of which the DAB's decision (if any) has not become final and binding shall be finally settled by Arbitration. Unless otherwise agreed by both Parties: (a) Any dispute or difference whatsoever arising between the parties and of or relating to the construction, interpretation, application, meaning, scope, operation or effect of this contract or the validity or the breach thereof, shall be settled by arbitration in accordance with Alternative Dispute Resolution Act of Bhutan 2013 and its Rules and Regulations 2019 and amendment thereof, (b) The number of arbitrators shall be three, and (c) the place of Arbitration shall be Bhutan. The cost and expenses of Arbitration proceedings will be borne by each party, as stipulated in the relevant Act. However, the expenses incurred by each party in connection with the preparation, presentation etc. of its proceedings shall be borne by each party itself, Provided always that no reference for arbitration shall be maintainable unless the Contractor deposits to the Employer a sum equal to 1.0% (one percent) of the amount under dispute and the sum so deposited shall, on the termination of the arbitration proceedings be adjusted against the cost, if any, awarded by the arbitral tribunal against the Contractor and the balance remaining after such adjustment or in the absence of any such cost being awarded, the whole of the sum will be refunded to him within one month from the date of the arbitral award. No interest shall be paid by the Employer on the amount deposited by the Contractor for referring the claim to arbitration. Performance under the Contract shall continue during the arbitration proceedings and payments due to the Contractor by the owners shall not be withheld, unless they are the subject matter of the arbitration proceedings.



	The Arbitral Tribunal shall give a written reasoned Award and the final award by a majority of Arbitrators rendered in writing shall be binding upon the parties.”



APPENDIX TO TENDER

Sl. No.	Sub-Clause	Data to be given	Data
1	1.1.2.2 & 1.3	Employer's name and address:	Khorlochhu Hydro Power Limited (KHPL), Post Box No. 46002, Doksum New Township, Trashiyangtse, Bhutan
2	1.1.2.3 & 1.3	Contractor's name and address:	To be provided by the Contractor
3	1.1.2.4 & 1.3	Engineer's name and address:	Will be nominated and intimated by the Employer.
4	1.1.3.3	Time for Completion of the Works:	42 months from the Date of Commencement
5	1.1.3.7	Defect Notification Period:	24 Months
6	1.2	Where Contract allows for Cost plus reasonable Profit, the percentage profit to be added is:	5% (five percent)
7	1.3	Electronic transmission systems:	Duly scanned copy of signed notices/communications by authorized representatives by electronic address (e-mail)
8	1.3(d)	Address of the Employer for communications:	General Manager, Contracts & Procurement Division, Khorlochhu Hydro Power Limited (KHPL), Post Box No. 46002, Doksum New Township, Trashiyangtse, Bhutan. Email: gm.cnp@khpl.bt
9	1.3(d)	Address of Engineer for communications:	Will be provided later
10	1.3(d)	Address of Contractor for communications:	Tenderer to complete _____ _____ ____ _____
11	1.4	Governing Law:	Law of the Kingdom of Bhutan
12	1.4	Jurisdiction:	Courts of Bhutan
13	1.4	Ruling language:	English
14	1.4	Language for communication:	English
15	2.1	Time for access to the Site:	Within 15 days from the Commencement Date
16	3.5	Idle Time Cost Claims:	Refer Annexure-I of Appendix to Tender

Sl. No.	Sub-Clause	Data to be given	Data
17	4.2	Amount of the Performance Security:	10% of the Accepted Contract Amount and as per the currency of the Bid. Additional Performance Securities as per Section-4, Particular Conditions of Contract under Sub Clauses 4.2.
18	4.8	Safety Procedures:	Refer Annexure-II of Appendix to Tender
19	5.1	Period for notifying any errors, faults and defects in the Employer's Requirements:	42 days calculated from the Commencement Date.
20	6.4	Contractor's Labour Regulations:	Refer Annexure-III of Appendix to Tender
21	6.7	Health and Safety:	Refer Annexure-IV of Appendix to Tender
22	8.7	Delay Damages for Interdependent Milestones	Refer Annexure-V of Appendix to Tender
23	8.7	Maximum Amount of Delay Damages on account of Works	10% of the Accepted Contract Amount
24	14.2	Total Advance Payment:	10% of the Accepted Contract Amount
25	14.2	Number and timing of instalments:	1 (one) only.
26	14.2	Currency or currencies and proportions	As per the currency and proportions of the Bid
27	14.6	Minimum amount of Interim Payment Certificates	1% of the Accepted Contract Amount
~~28~~	14.8	Financing Charges for delayed payment:	6% p.a. (simple interest).
29	14.15	Currency/Currencies of payment:	As per currency of the Bid
30	18.1	General requirements:	
		(i) Insuring Party	(i) Is the Contractor
		(ii) Evidence of insurance	(ii) 60 days from Commencement Date
		(iii) Relevant policies	(iii) 120 days from Commencement date
		(iv) Interest on payment made by Employer against Insurance Premium on behalf of Contractor	(iv) Base rate of RMA plus 2%
31	18.2	Amount of insurance required for Works (EAR Policy):	125 % of Accepted Contract Amount.
32	18.2	Amount of insurance required for Contractor's Equipment (CPM):	Full replacement value including delivery to site

Sl. No.	Sub-Clause	Data to be given	Data
33	18.2	Amount of insurance required for Goods:	125 % of Accepted Contract Price
34	18.2 (d)	Maximum amount of deductibles for insurance of the Employer's risks as well as other risks Amount of insurance required CPM	5 % of each loss subject to maximum of BTN/INR 5.0 million.
35	18.3	Minimum amount of Third Party Insurance:	Minimum amount of third-party insurance is BTN/INR 100.00 million per occurrence and on reinstatement basis
36	20.2	The DAB shall comprise of:	3 (three) members
37	20.3	Appointment (if not agreed) to be made by:	Director General/ Director, Department of Energy, Ministry of Economic Affairs, RGoB or such other officer as may be duly authorized by the RGoB from time to time for such an action.



Annexure - I of Appendix to Tender

(Refer GCC/PCC Sub-Clause – 3.5)

PROCEDURE FOR IDLING TIME COST CLAIMS

The valuation of idling time cost claims of the Contractor's shall cover compensation for idling time related cost as given below:

(a) Cost of owned Equipment

Cost of owned Equipment will comprise of the following elements:

i) Depreciation Cost

Annual Depreciation (Based on life in years)	= 0.90 × Book Value/Life in years
Depreciation Cost payable for idling	= [(Idle Period in days/365) × 0.67 × Annual Depreciation]

However, if the equipment has completed its scheduled life in years, in that case the depreciation shall be considered as zero.

ii) Interest on Capital Investment: (Rate of Interest* /100) × Average Annual Cost

The average annual cost is determined as follows:

Average Annual Cost	= Book value of Equipment × (n+1)/2n
Interest on Capital Investment payable for Idling Period	= [(Idle Period in days/365) x (Rate of Interest/100) × Average Annual Cost]

Where:

- "n" refers for number in years of life of equipment.
- Book Value = purchase price plus freight, insurance, all taxes and duties, port clearance charges, erection and commissioning charges and other incidental charges.
- Rate of Interest shall be 12% p.a. (simple rate of interest).

iii) Insurance Charges

Insurance charges payable during idling period in respect of Contractor's Plant & Machinery (CPM) policy shall be considered as per actual.

(b) Cost of Leased/Hired Equipment

In case of leased/hired equipment, the hire charges shall be admissible for the idle period. The value of the claim amount shall be assessed by the Owner/Employer, keeping in view documentary evidence provided by the Contractor, prevailing market rate and reasonableness of the claim.

NOTE: Cost of equipment either at (a) or (b) above shall be applicable for the specific equipment i.e. owned or hired or leased, as the case may be.

(c) Cost of Labour

The labour directly engaged for the works at Site by the Contractor or through Sub-Contractor, as verified by the Engineer, will be reimbursed for idle period in case Contractor produces proof that idle labour has been paid wages during the period of idling.

Cost of equipment related labour, as verified by Engineer, will be worked out as per CWC norms limited to actual whichever is lower.

The above cost will be considered for payment based on the supporting details such as attendance sheet, receipt of deposit of provident fund duly certified by the Contractor.

In addition to actual cost of labour, indirect charges shall be considered. The indirect charges (other than salary) shall be 80% and 55% for skilled and unskilled labour respectively. Indirect charges shall be applicable on the basic wages. Basic wages mean component of wages on which statutory deductions like Provident Fund is deposited to the statutory authority.

(d) Cost of Site staff

The Cost of site executives/supervisory staff shall be considered for payment as per actual. The site staff implies all the staff posted at the site excluding staff posted at the Head office. Cost of site staff shall be supported by relevant documents. The cost shall be considered for payment based on the supporting details in form of pay ledger, bank details, detailed pay slips, certificate of income tax deducted at source issued by the Contractor as well as Sub-Contractor's and receipt of deposit of Provident Fund duly certified by the Contractor. In this head, staff physically deployed at site shall only be considered.

(e) Overheads

Overhead costs include but not limited to Office and share of head office expenses, Legal charges, General establishment, Watch and Ward, Local conveyance, Travelling expenses, Social welfare, salaries of Managerial and clerical staff etc. and Publicity etc.

$$\text{Overhead Charges} = \frac{\text{5\% of Accepted Contract Amount} \times \text{Authorized Time Extension (in days) for Compensation Events}}{\text{Construction Period (in days) as per Letter of Acceptance}}$$

The lump-sum component of overhead as 5% shall cover all other charges not included expressly in any of the items of claim at Sl. (a) to (d) as above.

(f) Bank Guarantees and Insurance Charges

These charges are to be considered towards cost compensation for the idle period based upon documentary evidence of payment of premium/additional charges by the Contractor towards Insurance/Performance Bank Guarantee and Retention Money Bank Guarantee.

(g) The Taxes Applicable on Cost Claims

The applicable taxes on the above elements of cost claim shall be reimbursed to the Contractor as per actual based on the documentary evidence.



Annexure - II of Appendix to Tender

(Refer GCC/PCC Sub-Clause – 4.8)

SAFETY PRECAUTIONS

1. Safety Precautions

1.1 Suitable scaffolds shall be provided for workmen for all works that cannot safely be done from the ground, or from solid construction except such short period work as can be done safely from ladders. When a ladder is used, an extra workman shall be engaged for holding the ladder. If the ladder is used for carrying materials as well, suitable footholds and handholds shall be provided on the ladder and the ladder shall be given an inclination not steeper than 0.25 to 1 (0.25 horizontal and 1 vertical).

1.2 Scaffolding or staging more than 3.6 m above the ground or erected floor, swung or suspended from an overhead support or erected with stationary support shall have a guard rail properly attached, bolted, braced and otherwise secured at least 0.9 m high above the floor or platform of such scaffolding or staging and extending along the entire length of the outside and ends thereof with only such opening as may be necessary for the delivery of the materials. Such scaffolding or staging shall be so fastened as to prevent it from swaying from the structure.

1.3 Working platform, gangways and stairways shall be so constructed that they do not sag unduly or unequally, and if the height of the platform or the gangway or the stairway is more than 3.6 m above ground level or floor level, they shall be closely boarded, and shall have adequate width and shall be suitably fastened as described in para 7.1 above.

1.4 Every opening in the floor of a structure or in a working platform shall be provided with suitable means to prevent the fall of persons or materials by providing suitable fencing or railing whose minimum height shall be 0.9 m. Employees working on steep slopes or otherwise subject to possible falls from levels not protected by guardrails or safety nets, shall be secured by safety belts and lifelines.

1.5 Safe means of access shall be provided to all working platforms and other working places. Every ladder shall be securely fixed. No portable single ladder shall be over 9.0m in length while the width between side rails in hung ladder shall, in no case, be less than 28 cm. for ladder up to and including 3.0 m in length.

For longer ladders, this width shall be increased at least by 6mm for each additional 30 cm of length. Uniform step spacing shall not exceed 30 cm. Adequate precautions shall be taken to prevent danger from electrical equipment. No materials on any of the Sites of Work shall be so stacked or placed as to cause danger or inconvenience to any person or the public.

1.6 All trenches, 1.2 m or more in depth, shall, at all times, be supplied with at least one ladder for each 30 metres length of fraction thereof. Ladder shall be extended from bottom of the trench to at least 0.9 m above the surface of the ground. The side of the trenches which are 1.5 m or more in depth shall be stepped back to give suitable slope or securely held by timber bracing, so as to avoid the danger of sides to collapse. The excavated materials shall not be placed within 1.5 m of the edges of the trench or half of the depth by the trench whichever is more. Cutting shall be done from top to bottom. Under no circumstances undermining or undercutting shall be done.

1.7 Before any demolition work is commenced and also during the process of the Work:

i) All roads and open areas adjacent to the Site shall either be closed or suitably protected.

ii) No electric cable or apparatus which is liable to be a source of danger over a cable or apparatus used by the operator shall remain electrically charged.

iii) All practical steps shall be taken to prevent danger to persons employed from risk of fire or explosion or flooding. No floor, roof or other part of the structure shall be overloaded with debris or materials as to render it unsafe.

1.8 All necessary personal safety equipment as considered adequate by the Engineer shall be kept available for the use of the persons employed on the Site and maintained in conditions suitable for immediate use, and the Contractor shall take adequate steps to ensure proper use of equipment by those concerned.

i) Workers employed on mixing asphaltic materials, cement mortar and cement concrete shall be provided with protective footwear and protective goggles.

ii) Those engaged in mixing or stacking of cement bags or any materials which is injurious to eyes shall be provided with protective goggles.

iii) Those engaged in welding works shall be provided with welder's protective eye shields.

iv) Stone breakers shall be provided with protective goggles and protective clothing and seated at sufficiently safe intervals.

v) The Contractor shall not employ any person below the age of 18 years. Whenever a person above the age of 18 years is employed on the work of lead painting, the following precautions shall be taken:

a) No paint containing lead, sulphate of lead or products containing heir pigments shall be used except in the form of paste or readymade paint.

b) Suitable face masks shall be supplied for use by the workers when paint is applied in the form of spray or a surface having lead paint dry rubbed and scrapped.

c) Overalls shall be supplied by the Contractor to the workmen and adequate facilities shall be provided to enable the working painters to wash during the cessation of Work.

d) Measures shall be taken, whenever required, in order to prevent danger arising from the application of a paint in the form of spray.

e) Measures shall be taken, whenever practicable, to prevent danger arising out of dust caused by dry rubbing down and scrapping.

f) Suitable arrangements shall be made to prevent clothing put off during working hours, being spoiled by painting materials.

g) Cases of lead poisoning and suspected lead poisoning shall be notified and shall be subsequently verified by a medical officer appointed by the competent authority of the Employer.

h) The Employer, when necessary, shall arrange for medical examination of workers.

i) Instructions with regard to special hygienic precautions to be taken in the painting trade shall be distributed to working painters.

j) The Contractor shall observe all safety precautions to control the noise on all Sites and also provide all workmen deployed in the affected areas with the necessary equipment for safety against noise.

1.9 When the Work is done near any place where there is risk of drowning, all necessary equipment shall be provided and kept ready for use and all necessary steps taken for prompt rescue of any person in danger and adequate provision shall be made for prompt first aid treatment of all injuries likely to be sustained during the course of the Work.

1.10 Use of hoisting machines and shackle including their attachments, anchorage and supports shall conform to the following standards or conditions:

i) These shall be of good mechanical construction, sound materials and adequate strength and free from patent defect and shall be kept in good working order.

ii) Every rope used in hoisting or lowering materials or as a means of suspension shall be of durable quality and adequate strength and free from patent defects.

iii) Every crane driver or hoisting appliance operator shall be properly qualified for his job.

iv) In case of every hoisting machine and of every chain ring hook, shackle swivel and pulley block used in hoisting or a means of suspension, the safe working load shall be ascertained by adequate means. Every hosing machine and all gears referred to above shall be plainly marked with the safe working load.

In case of hoisting machine having a variable safe working load, each safe working load and the conditions under which it is applicable shall be clearly indicated. No part of any machine or any gear referred to above in this paragraph shall be loaded beyond the safe working load except for the purpose of testing. The capacity of the hoisting machines shall be periodically checked.

v) The Contractor shall notify the safe working load of the machines to the Engineer whenever he brings any machinery to Site of work and get it verified by the Engineer or his representative.

1.11 Motors, gearing, transmission, electric wiring and other wiring and other dangerous parts of hoisting appliances shall be provided with efficient safeguards. Hoisting appliances shall be provided with such means as shall reduce to the minimum, the risk of any part of a suspended load becoming accidentally displaced. When workmen are employed on or near electrical installations which are already energized, insulating mats, wearing apparel, such as gloves, sleeves and boot, as may be necessary, shall be provided. The workers shall not wear any rings, watches and carry keys or other materials which are good conductors of electricity.

1.12 All scaffolds, ladders and other safety devices mentioned or described herein shall be maintained in safe conditions and no scaffold, ladder or equipment shall be altered or removed while it is in use. Adequate washing facilities shall be provided at or near place of work.

1.13 These safety provisions shall be brought to the notice of all concerned by display on a notice board at a prominent place on the Site. The person responsible for compliance of the safety code shall be named therein by the Contractor.

1.14 To ensure effective enforcement of the rules and regulations relating to safety precautions, the arrangements made by the Contractor shall be open to inspection by the Labour Officer or the Engineer.

1.15 In addition to above, the Contractor shall take the following specific precautions for the underground works:

i) All precautions regarding safety of personnel working in tunnels / caverns / shafts, in connection with the handling of electric installations, loading, blasting and seepage water etc. as specified in the relevant stipulations of IS codes shall be taken by the Contractor in order to ensure safe underground working. He shall also provide adequate medical, drinking water, sanitation, lighting and ventilation facilities.

ii) Emergency material shall be provided at each underground excavation heading. This equipment shall include, but not be limited to the following:

- 3 stretchers
- 3 woolen blankets
- 2 appliances for artificial breathing

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- 1 oxygen flask
- 3 explosion – proof lamps
- Wound dressing and disinfection material
- Anti pain injections
- Gas masks

iii) At least two members of the Rescue Team as described hereinafter, properly instructed and trained in the rescue procedures, shall be in each crew working ground.

iv) Prior to the commencement of construction, the Contractor shall organize and train a Rescue Team composed of his employees. This Rescue Team shall be capable of rendering help after accidents caused by fire, gas explosion and avalanche etc.

v) The Rescue Team shall be organized in such a way that sufficient number of members are ready for action at any time until the Completion of works.

vi) The Rescue Team shall be instructed and trained for their task by a qualified and experienced person. If required, the Contractor shall hire an outside specialist to impart such training. A refresher training for all members of the Rescue Team shall be conducted at least every six months.

vii) Each Rescue Team member shall be skilled in giving the first aid, dealing with the appliances for artificial respiration and firefighting equipment and shall possess a good local knowledge. Adequate equipment for reaching even the remotest working area shall be at their disposal.

viii) The Contractor shall submit the details of the proposed Rescue Team organization to the Engineer for approval.

1.16 The Contractor shall at all times exercise reasonable and proper precautions for the safety of the people engaged in the construction of the Works and shall comply with the provisions of current safety laws and building and construction codes as may be applicable. All machinery and equipment and other sources of physical hazards shall be properly guarded.

The Contractor shall have a full-time staff exclusively in-charge of securing the safety of the Works ensuring that all safety regulations are followed and in – charge of indoctrination and teaching courses on safety to the work force.

1.17 The Contractor shall provide all necessary fencing and lights to protect the public from accidents and shall be bound to bear all the expenses of defense of every suit, action and other proceedings at Law that may be brought by any person for injury sustained owing to neglect of the above precautions and to pay any damages and costs which may be awarded in any such suit, action and proceedings to any such persons or which may, with the consent of the Contractor, be paid to compromise any claim by any person.

1.18 About his employees, the Contractor shall ensure as follows:

i. Each employee shall be provided initial indoctrination regarding safety by the Contractor so as to enable him to conduct his work in a safe manner.

ii. No employee shall be given a new assignment of work unfamiliar to him without proper introduction as to the hazardous incident thereto, both to himself and his fellow employees.

iii. Under no circumstances shall an employee hurry or take unnecessary chances when working under hazardous conditions.

iv. Employees shall not leave naked fire unattended. Adequate firefighting equipment shall be provided at crucial locations.

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v. Employees under the influence of any intoxicating beverage, even to the slightest degree, shall not be permitted to remain on work.

vi. There shall be a suitable arrangement on every site for rendering prompt and sufficient first aid to the injured under the guidance of the Medical Officer.

vii. The staircase and passage ways shall be adequately lighted.

viii. The employees, when working around moving machinery, shall not be permitted to wear loose garments. Safety shoes are recommended when working in shops or places where materials or tools are likely to fall. Only experienced workers shall be permitted to go behind guard rails or to clean around energized or moving equipment.

ix. The employees shall use the standard protection equipment intended before and after it is used.

1.19 The following precautions shall be taken for fire prevention:

i. All construction areas and storage yards shall be kept clean and well arranged.

ii. A clear space of 15 meters around the outer boundary of saw mill and lumber storage area may be provided. All lumber shall be stored in section with fire breaks with a distance of 15 meter between consecutive sections.

iii. All combustible waste material, wood scaling and soiled rag etc. shall be removed daily and burnt in suitable burning areas. The saw mill and lumber yard shall be kept free from accumulation of combustible debris.

iv. Fire, welding, flame cutting shall in general not permitted in combustible areas. Fires and open flame devices shall not be left unattended.

v. Smoking shall be prohibited in all fire prone areas, flammable material storages viz. carpentry, paint shops, garages, service stations etc. “No Smoking” signs shall be pasted on all such areas.

vi. Accumulations of flammable liquids on floors, walkways, etc. should be prohibited. All spills of flammable liquids shall be cleaned up immediately.

vii. Smoke pipes from Diesel Engines passing through roof of combustible material e.g. in compressor stations on various sites shall be insulated by asbestos. All joints of smoke pipe shall be riveted, welded or otherwise securely fastened together and supported to prevent accidental displacement or separation. The joints shall not be leaky.

viii. Flammable liquids, lubricants etc. shall be handled and transported in safety containers and drums which can be kept tightly capped.

ix. Storage of fuels and other flammable materials and liquids shall be set not less than 100 m away from the Works and permanent installations. All storage installations and tanks conform to the regulations set out in relevant Indian Standards.

x. Petrol or other flammable liquids with a flash point below 100 degrees Centigrade shall not be used for cleaning purpose.

xi. Oxygen cylinders shall not be stored with combustible materials.

xii. All electric installations shall be properly earthed. Repair shall not be made on electrical circuits until the circuit has been de-energized.

1.20 The following firefighting arrangements shall be made by the Contractor.

i. Fire extinguishers and fire buckets, painted red, shall be provided at all fire hazardous locations viz. Batching and Mixing Plants, Winch houses, Workshops, Store yards, saw-mill, switch gear room, compressor stations, officer establishments etc. The extinguishers shall be inspected, serviced and maintained in accordance with

manufacturer's instructions. The inspection shall be evidenced by notations on tag attached to the extinguisher.

ii. Full reliance shall be placed on portable hand extinguishers as all of these have a very limited capacity. Water, in ample quantity and under adequate pressure, shall always be available for firefighting.

iii. Where a group of work points water supply, the installation of a water system for private fire protection shall be warranted.

iv. Evacuation facilities and fire exit shall be provided at all locations featuring fire hazards.

v. Siren or other suitable fire alarm arrangement shall be made on all Sites. Warning signs shall be pasted at all locations having fire hazards.

vi. All staff shall be conversant with the use of all types of fire extinguishing apparatus.

vii. Demonstrations and training in firefighting shall be conducted at sufficient intervals to ensure that sufficient personnel are familiar with and are capable of operating firefighting equipment.

1.21 When any work is carried on, which is likely to affect the security or stability of an installation or structure or any part thereof and endanger any person employed, all practicable precautions shall be taken by shoring or otherwise to prevent collapse of structure or fall of any part thereof and thus remove the cause of danger to such structures and the persons employed.

1.22 For person engaged in handling of corrosive materials, adequate equipment shall be provided.

1.23 Where, in connection with any grinding, cleaning, spraying or manipulation of any material, there is emission of any dust or fume of such character and to such extent as is likely to be injurious to the health of persons employed, all practical measures shall be taken by securing adequate ventilation or by the provision and use of suitable respirators or otherwise to prevent inhalation of such dust and fume.

1.24 In addition to instructions contained here-in-above the safety regulations contained in the following IS codes or the latest amendments thereof shall also apply wherever the provisions in the codes are exhaustive in nature.

i.	IS : 3764-1992	Safety code for excavation of work
ii.	IS : 4756 – 1978 (Reaffirmed 1991)	Safety code for Tunneling work
iii.	IS : 7293 – 1974 (Reaffirmed 1991)	Working with construction machinery
iv.	IS : 7969-1975 (Reaffirmed 1991)	Handling and storage of building material
v.	IS : 4081-1986 (Reaffirmed 1991)	Blasting and related drilling operations
vi.	IS : 3696-1987 (Part-I) (Reaffirmed 1991)	Scaffolds & Ladders (Pt. I Ladders)
vii.	IS : 3696-1991 (Part-II)	Scaffolds & Ladders (Pt. II Ladders)
viii.	IS : 4138-1977 (Reaffirmed 1991)	Working in compressed air (Ist revision)
ix.	IS : 4130-1991	Demolition of Buildings (Ist Revision)

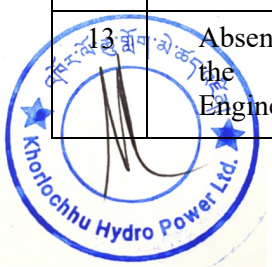
x.	IS: 5916 – 1970 (Reaffirmed 1990)	Construction involving use of Hot Bituminous materials
xi.	IS: 3016-1982	Fire protection in welding and cutting operations
xii.	IS: 5878-1971 (Reaffirmed 1990)	Code of Practice for Construction of Tunnels (Part – II Sec.2)

1.25 Notwithstanding the above provisions, the Engineer may require the Contractor to follow any other Act or Rules in force in Bhutan in respect of Safety Precautions so as to ensure the safety of the Workmen and the Constructional Plant and the Contractor shall promptly comply with such requirements.



AMOUNT OF PENALTY TO BE LEVIED ON NON-COMPLIANCE ORREPEATED FAILURE IN IMPLEMENTATION OF REQUISITE SAFETY MEASURE

Sl. No.	Violation of safety requirement	Penalty Amount
1	For not using personal protective equipment (Helmet, Shoes, Goggles, Gloves, Full body harness, Boiler suit etc.)	Nu. 250/- per day item/Person
2	Working without Permit/Clearance	Nu. 5,000/- per head per occasion
3	Degradation of environment (not confining toxic spills, spilling oil/lubricants, bentonite, etc. onto ground)	Nu. 3,000/- per occasion
4	Improper handling, storage & transportation of blasting material/equipment.	Nu. 3,000/- per occasion
5	Unsafe electrical practices (non-installation of ELCB, using poor joints of cables, using naked wire without top plug into socket, laying wire/cables on the roads electrical jobs by incompetent person).	Nu. 3,000/- per item per day
6	Working at height without full body harness using non-standard scaffolding and not arranging fall protection arrangement as required.	Nu. 3,000/- per item per day
7	Unsafe handling of compressed gas cylinders (no trolley, jubilee clips double gauge regulator, improper storage/handling).	Nu. 100/- per item per day
8	Use of domestic LPG for cutting purpose.	Nu. 1,000/- per occasion
9	Non-fencing barricading of excavated areas.	Nu. 1,000/- per occasion
10	Non-display of caution boards, list of hospitals, emergency services available at work locations.	Nu. 500/- per occasion
11	Non-providing shoring/shafting/proper slope and not keeping the excavated earth at least 1.5m away from excavated areas.	Nu. 5000/- per occasion
12	Traffic rules violations like over speeding of vehicles rash driving, wrong parking, not using seat belts, vehicles not fitted with reverse warning alarms, flashing sirens.	Nu. 5000/- per occasion
13	Absence of Contractor's top most executive at item in the safety meetings whenever called by Engineer/Employer	Nu. 1,000/- per meeting



Sl. No.	Violation of safety requirement	Penalty Amount
14	Failure to maintain safety records like air quality monitoring reports, records of regular inspections of work areas, etc.	Nu. 1,000/- per occasion
15	Poor House keeping	Nu. 1,000/- per occasion
16	Failure to report & follow up accident (including Near Miss)	Nu. 1,000/- per occasion
17	Violation of any other safety condition as per job plan, work permit and conditions of contract such as using crowbar on cable trenches, improper welding booth, not keeping fire extinguisher ready at hot work site, unsafe rigging etc.	Nu. 1,000/- per occasion
18	Any violation not covered above	To be decided by Engineer

Note: The penalties listed above are over and above the penalties that may be levied by the statutory authorities/local bodies.

Annexure - III of Appendix to Tender

(Refer GCC/PCC Sub-Clause – 6.4)

CONTRACTOR'S LABOUR REGULATIONS

2.1 SHORT TITLE

These regulations may be called the "the Contractor's Labour Regulations."

2.1 DEFINITIONS

In these regulations, unless otherwise expressed or indicated, the following words and expressions shall have the meaning hereby assigned to them respectively.

"Labour" means workers employed by the Contractor directly, or indirectly through a Subcontractoror other persons or by an agent on his behalf but shall not include supervisory staff like Section Officers etc. For the avoidance of doubt, the word 'Labourers' shall be construed accordingly.

"Fair Wage" means wage whether for time or piece work notified at the time of inviting tenders for the Works and where such wages have not been so notified, the wages prescribed by the Employer for the area in which the work is done. Such wages shall at no time be less than the minimum wages fixed by the Royal Government of Bhutan under applicable Law for that class of Labour engaged on the same type of work in the same area.

"Contractor" shall mean and include the Contractor and every person whether a Subcontractoror head-man or agent, employing Labour for the Works undertaken under the Contract.

2.1 DISPLAY OF NOTICE REGARDING WAGES, ETC.

The Contractor shall:

a) before he commences the work under the Contract, display and correctly maintain and continue to display and correctly maintain in a clean and legible condition in conspicuous place on the Site, notices in English and in Hindi and local language spoken by the majority of the Labour mentioning the rate of wages which have been certified by the Engineer as fair wage and the hours of work for which such wages are earned.

Normally the working hours of any Labourers should not exceed 9 (nine) hours a day. The working day shall be so arranged that inclusive of interval for rest, if any, it shall not spread over more than 12 (twelve) hours on any day.

2.1 PAYMENT OF WAGES

i) Wages due to each Labourer shall be paid to him directly.

ii) Arrears claimed after 3 months after the completion of the Works shall not be entertained by the Contractor.

iii) All wages shall be paid in current coin/currency.

2.1 FIXATION OF WAGE PERIODS

i) The Contractor shall fix the wage periods in respect of which the wages shall be payable.

ii) No wage period shall exceed one month.

iii) Wages of each Labourer employed on the Contract shall be paid;

a) in the case of establishment for whom wage period is one week, within 3 days from the end of the wage period; and

b) in the case of other establishments before the expiry of the 7th day and 10th day from the end of the wage period for the number of Labourers employed in such establishment not exceeding 1000 and exceeding 1000 respectively.

iv) When the employment to any Labourer is terminated by or on behalf of the Contractor, the wages earned by him shall be paid before the expiry of the day succeeding the one on which his employment is terminated.

v) All payments of wages shall be made on a working day except when the work is completed before the expiry of the wage period in which case final payment shall be made within 48 hours of the last working day at the Site and during the usual working time.

2.1 WAGE BOOK AND WAGE SLIPS ETC

i) The Contractor shall maintain a Wage Book of each Labourer in such forms as may be convenient at the place of Works; the same shall include inter alia the following particulars:

- Name of the Labourer.
- Rate of daily or monthly wages.
- Nature of work on which employed.
- Total number of days worked during each wage period.
- Dates and periods for which worked overtime.
- Gross wages payable for the work during each wage period.
- All deductions made from the wage with an indication in each case of the ground on account of which the deduction is made.
- Wages actually paid for each wage period.
- Signature or thumb impression of the Labourer.

ii) The Contractor shall also issue a wage slip containing the aforesaid particulars to each Labourer employed by him on the Works at least a day prior to the day of disbursement of wages.

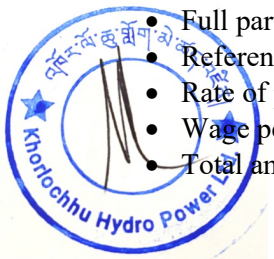
iii) The Contractor shall also issue an employment card in the prescribed Form-I (attached) to each Labourer on the day of work or entry into his employment.

iv) The Contractor shall issue an attendance cum wage card as per Form-II to each Labourer on the day of entry into his employment.

2.1 REGISTER OF UNPAID WAGES

The Contractor shall maintain a register of unpaid wages in such form as may be convenient at the place of work but the same should include inter alia the following particulars.

- Full particulars of the Labourers whose wages have not been paid.
- Reference number of the muster roll and wage register.
- Rate of period.
- Wage period.
- Total amount not paid.



- Reasons for not making payment.
- How the amount of unpaid wages was utilized.
- Acquaintance with dates.

2.1 REGISTER OF ACCIDENTS

The Contractor shall maintain a register of accidents in such form as may be convenient at the work place, but the same should include the following particulars;

- Full particulars of the worker(s) who met with accident.
- Rate of wages.
- Sex.
- Age.
- Nature of accident and cause of accident.
- Time and date of accident.
- Date and time when admitted in hospital.
- Date of discharge from the hospital.
- Period of treatment and result of treatment.
- Percentage of loss of earning capacity and disability assessed by medical officer.
- Compensation required to be paid.
- Date of payment of compensation.
- Amount paid with details of the person to whom the same was paid.
- Authority by whom the compensation was assessed.
- Remarks.

2.1 FINES AND DEDUCTIONS WHICH MAY BE MADE FROM WAGES

i) The wages of a Labourer shall be paid to him without any deductions of any kind except the following;

Fines

Deductions for absence from duty i.e. from the place or the places where, by the terms of his employment he is required to work. The amount of deduction shall be in proportion to the period during which he was absent.

Deduction for damage to or loss of goods expressly entrusted to the employed person for custody, or for loss of money or any other deduction which he is required to account, where such damage or loss is directly attributable to his neglect or default.

Deduction for recovery of advance or for adjustment of over payment of wages, advances granted shall be entered in a register.

Any other deduction which the Employer may from time to time allow.

ii) No fine should be imposed on any Labourer save in respect of such acts and omissions on his part as have been approved of by the Engineer.

iii) No fine shall be imposed on a Labourer and no deduction for damage or loss shall be made from his wages until the Labourer has been given an opportunity of showing cause against such fines or deductions.

2.1 REGISTER OF FINES ETC.

i) The Contractor shall maintain a register of fines and a register of deductions for damages or loss in Form Nos. III & IV respectively which should be kept at the places of work.

ii) The Contractor shall maintain both in English and in the local language, a list approved by the Engineer clearly stating the acts and omissions for which penalty or fine may be imposed on a Labourer and display it in a good condition in a conspicuous place of the work.

2.1 PRESERVATION OF REGISTER

The wage book, the wage slips, register of unpaid wages, the resister of accidents, the register of fines, deduction required to be maintained under these regulations shall be preserved for 12 months after the date of last entry made in them and shall be made available for inspection by the Engineer, Labour Officer or any other officer authorized by the Employer in this behalf.

2.1 POWERS OF LABOUR WELFARE OFFICERS TO MAKE INVESTIGATION OR ENQUIRY

The Labour Welfare Officer or any other person authorized by the Employer on its behalf shall have power to make enquiries with a view to ascertaining and enforcing due and proper observance of the fair wage clauses and the provisions of these regulations. He shall investigate into any complaint regarding the default made by the Contractor or Subcontractorin regard to such provision.

2.1 REPORT OF LABOUR WELFARE OFFICER

The Labour Welfare Officer or other persons authorized as aforesaid shall submit a report or result of his investigation or enquiry to the Engineer indicating the extent, if any, to which the default has been committed, with a note that necessary deductions from the Interim Pay Certificate of the Contractor be made and the wages and other dues be paid to the Labourer(s) concerned. In case an appeal is made by the Contractor under Para 1.14 of these regulations, actual payment to Labourer(s) will be made by the Engineer or authorized agent after the Employer has given its decision on such appeal.

The Engineer shall arrange payments to the Labourers concerned within 45 days from the receipt of the report from the Labour Welfare Officer.

2.1 APPEAL AGAINST THE DECISION OF LABOUR WELFARE OFFICER

Any person aggrieved by the decision and recommendations of the Labour Welfare Officer or other person so authorized may appeal such decision to the Engineer, within 30 days from the date of decision. The decision of the Engineer shall be final and binding upon the Contractor.

2.1 INSPECTION OF BOOKS AND SLIPS

The Contractor shall allow inspection of the wage books and the wage slips, register of unpaid wages, register of accidents, the register of finds and deductions to any of his Labourers or to his agent at a convenient time and place after due notice is received or to the Labour Welfare Officer or any other persons, authorized by the Engineer on his behalf.

2.1 SUBMISSION OF RETURNS

The Contractor shall submit periodical returns as may be specified from time to time.

2.1 AMENDMENTS

The Employer may from time to time add to or amend the regulations and on any question as to the application, interpretation or effect of those regulations, the decision of the Engineer or of his authorized representative shall be final.



Form - I: Employment Card Regulation

Name & Sex of the worker	Age or date of birth
Father's Name	Identification marks
	(Particulars of next of kin wife and children, if any, or of dependent next to kin in case the worker has no wife or child)
Photograph	Name…….. Full address of dependents (Specify village, district, state and country).

Sl. No	Name and address of employer (Specify whether a contractor or Sub-contractor	Particulars of location work site and description of work done	Total period for which the worker is employer (from….to……)	Actual number of days worked	Leave taken (Number of days should be Specified)
1.	2.	3.	4.	5.	6.

FORM-I (Contd.)

(BACK SIDE OF THE CARD)

Nature of work done by the workers	Wage period	Wage rate (with particulars of unit in case of piece work)	Total wage earned by the worker during the period shown under column (5)	Remarks	Signature of the employer
7.	8.	9.	10.	11.	12.

Form - II: Attendance-Cum-Wage Card

[Referred to Para 1.6 (iv)]

Card No……..

Name of Contractor……

Name of work……

Name of worker…….

Address…….

Designation……

Rates of wages……..

Dates	Attendance	Signature of person making attendance	Remarks
1			
2			
3			
4			
5			
Etc.			

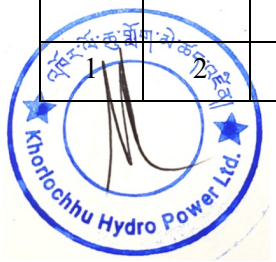
Wage period	Date on which overtime	Gross wage payable	Deductions if any	Actual wages paid	Date of payment	Signature of the Worker

Form – III: Register of Fines
(REGULATION 1.10 (i)

Sl. No.	Name	Father's / Husband Name	Sex	Department	Nature & Date of the offence for which fine imposed	Whether workmen showed cause against fine or not, if so, enter date	Rate of wages	Date and amount of fine imposed	Date on which fine Realized	Remarks
1	2	3	4	5	6	7	8	9	10	11

Form – IV: Register of Deductions for Damages or Loss Regulation 1.10 (i)

Sl. No.	Name	Father's / Husband Name	Sex	Department	Damage or loss caused with date	Whether worker showed cause against deduction if so, enter date	Date of amount of deduction imposed	Number of installments if any	Date on which total amount realized	Remarks
1	2	3	4	5	6	7	8	9	10	11



Annexure - IV to Appendix to Tender

Refer GCC/PCC Sub-Clause-6.7

HEALTH AND SANITARY ARRANGEMENTS FOR CONTRACTOR'S WORKMEN

1.1 APPLICATION

These rules shall apply to all construction works under the charge of the Employer

1.2 DEFINITIONS

i) "Work Place"/or work site means a place at which, at an average 50 or more workers are employed, in connection with construction work.

ii) "Large Work Place" or large work site means a place at which an average 500 or more workers are employed in connection with construction work.

1.3 FIRST AID

a) At every Work Place, there shall be maintained in a readily accessible place first aid appliances including an adequate supply of sterilized dressings and sterilized cotton wool. The appliances shall be placed in good order and in a Large Work Place, they shall be placed under the charge of a responsible person who shall be readily available during working hours.

b) At Large Work Places, where hospital facilities are not available within easy distance of the work, First Aid posts shall be established and run by trained compounders.

c) Where Large Work Places are remote from regular hospitals, an indoor ward shall be provided with one bed for every 250 employees.

d) Where Large Work Places are situated in cities/towns or in their suburbs and no beds are considered necessary owing to the proximity of city or town hospitals, suitable transport will be provided to facilitate removal of emergent cases to the hospitals. At other Work Places, some conveyance facilities such as car, shall be kept readily available to take injured person(s) or person(s) suddenly taken seriously ill, to the nearest hospital.

1.4 DRINKING WATER

a) In every Work Place, there shall be provided and maintained at suitable places easily accessible to labour, a sufficient supply of cold water fit for drinking.

b) Where drinking water is obtained from an intermittent public water supply, each Work Place shall be provided with storage where such drinking water shall be stored.

c) Every water supply storage shall be at distance of more than 15 meters from latrine, drain or any other source of pollution. Where water has to be drawn from an existing well which is within such proximity of latrine, drain or any other source of pollution, the well shall be properly chlorinated before water is drawn from it for drinking. All such wells shall be entirely closed in and be provided with a trap door which shall be dust and water proof.

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d) A reliable pump shall be fitted to each covered well, the trap door shall be kept locked and opened for cleaning or inspection which shall be done at least once in a month.

1.5 WASHING AND BATHING PLACES

i) Adequate washing and bathing places shall be provided, separately for men & women.

ii) Such places shall be kept in a clean and drained condition.

1.6 LATRINES AND URINALS

There shall be provided within the precincts of every Work Place adequate number of latrines and urinals in an accessible place. If women are employed, separate urinals and latrines shall be provided for them. All these shall be cleaned regularly and kept in a good sanitary condition.

1.7 DISPOSAL OF EXCRETA

Unless otherwise arranged for by the local sanitary authority, arrangements for proper disposal of excreta by incineration at the Work Place shall be made by means of a suitable incinerator approved by the local health officer or Engineer. Alternatively, excreta may be disposed of by putting a layer of nightsoil at the bottom of pucca tank prepared for the purpose and covering it with a 150 mm layer of waste or refuse and then covering it with a layer of earth for a fortnight (when it will turn into manure).

1.8 PROVISION OF SHELTER FOR REST

At every work place there shall be provided free of cost, for the use of workers, two suitable sheds, one for meals and the other for rest.

1.9 CRECHES

At very Work Place, at which 50 of more women workers are ordinarily employed, there shall be provided a crèche for the use of children, belonging to such women.

1.10 CANTEEN

A hygienic cooked food canteen on a moderate scale shall be provided for the benefit of workers wherever it is considered expedient.



Annexure - V of Appendix to Tender

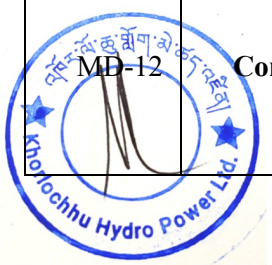
(Refer GCC/PCC Sub-Clause-8.7)

DELAY DAMAGES FOR INTERDEPENDENT MILESTONES

Milestone No.	Description of Interdependent Milestones	Completion in Days from Commencement Date	Amount of Delay Damages per Day for the part of Works covered by each Milestone Date
MD-1	Submission of data and general drawings of all relevant electrical and mechanical equipment, showing all relevant dimensions for the purpose of proper definition of all the tunnel and cavern excavation contours.	120	0.05% of Accepted Contract Amount per day of Delay limited to maximum of 1.0% of Accepted Contract Amount .
MD-2	Submission of detail design and drawings of all electrical and mechanical equipment, including the loads and forces to be considered for the structural design of the civil works, including earthing facilities, including all steel parts and everything else, which has to be embedded in the primary and secondary concrete and considered in the design of the Civil.	270	0.05% of Accepted Contract Amount per day of Delay limited to maximum of 1.0% of Accepted Contract Amount
MD-3	Erection, Testing & Commissioning of Powerhouse EOT Crane	420	0.05% of Accepted Contract Amount per day of Delay limited to maximum of 2.0% of Accepted Contract Amount
MD-4	Installation, Testing & Commissioning of all Generator Step Up Transformers, Shunt Reactor, 420kV GIS, XLPE Cables and associated Equipment.	1220	0.05% of Accepted Contract Amount per day of Delay limited to maximum of 2.0% of Accepted Contract Amount
MD-5	Erection, Testing & Commissioning of Penstock Valves.	1170	0.05% of Accepted Contract Amount per day of Delay limited to maximum of 2.0% of Accepted Contract Amount



Milestone No.	Description of Interdependent Milestones	Completion in Days from Commencement Date	Amount of Delay Damages per Day for the part of Works covered by each Milestone Date
MD-6	Completion of Electro-mechanical works in Pothead yard.	1220	0.05% of Accepted Contract Amount per day of Delay limited to maximum of 2.0% of Accepted Contract Amount.
UNIT-1			
MD-7	Lowering of Stator in Unit -1	1105	0.05% of Accepted Contract Amount per day of Delay limited to maximum of 3.0% of Accepted Contract Amount
MD-8	Lowering of Rotor in Unit -1	1110	0.05% of Accepted Contract Amount per day of Delay limited to maximum of 3.0% of Accepted Contract Amount
MD-9	**Commissioning of Unit -1**	1240	0.05% of Accepted Contract Amount per day of Delay limited to maximum of 3.0% of Accepted Contract Amount
UNIT-2			
MD-10	Lowering of Stator in Unit-2	1110	0.05% of Accepted Contract Amount per day of Delay limited to maximum of 3.0% of Accepted Contract Amount
MD-11	Lowering of Rotor in Unit-2	1120	0.05% of Accepted Contract Amount per day of Delay limited to maximum of 3.0% of Accepted Contract Amount
MD-12	**Commissioning of Unit-2**	1250	0.05% of Accepted Contract Amount per day of Delay limited to maximum of 3.0% of Accepted Contract Amount



Milestone No.	Description of Interdependent Milestones	Completion in Days from Commencement Date	Amount of Delay Damages per Day for the part of Works covered by each Milestone Date
UNIT-3			
MD-13	Lowering of Stator in Unit-3	1225	0.05% of Accepted Contract Amount per day of Delay limited to maximum of 3.0% of Accepted Contract Amount
MD-14	Lowering of Rotor in Unit-3	1230	0.05% of Accepted Contract Amount per day of Delay limited to maximum of 3.0% of Accepted Contract Amount
MD-15	**Commissioning of Unit-3**	1260	0.05% of Accepted Contract Amount per day of Delay limited to maximum of 3.0% of Accepted Contract Amount
UNIT-4			
MD-16	Lowering of Stator in Unit-4	1230	0.05% of Accepted Contract Amount per day of Delay limited to maximum of 3.0% of Accepted Contract Amount
MD-17	Lowering of Rotor in Unit-4	1240	0.05% of Accepted Contract Amount per day of Delay limited to maximum of 3.0% of Accepted Contract Amount
MD-18	**Commissioning of Unit-4**	1270	0.05% of Accepted Contract Amount per day of Delay limited to maximum of 3.0% of Accepted Contract Amount
MD-19	**Completion of Works in all respect**	1280	0.10% of Price Accepted Contract Amount limited to maximum of 10% of Accepted Contract Price.
These listed Milestone Dates shall be considered by the Contractor for submission of detailed Programme, which shall be a part of the Bidding Document.			

Annexure – VI of Appendix to Tender

(Refer GCC/PCC Sub-Clause-13.8)

WEIGHTAGES FOR PRICE ADJUSTMENT FORMULA

Components	Fixed Portion	Labour	Steel	Copper	HSD	M/C Tools
	A	**PL**	**PS**	**PC**	**F**	**E**
1) Supply of Electro-Mechanical Equipment						
a) For Electrical Equipment	0.15	0.35	0.30	0.15	-	-
b) For Mechanical Equipment	0.15	0.65	0.50	-	-	-
c) For Generator Transformer	*To be regulated as IEEMA, as stated under PCC, Part-B, Special Provisions, Sub-Clause 13.7.*					
2) Erection, Testing & Commissioning	0.15	0.60	-	-	0.10	0.15

Annexure - VII of Appendix to Tender

(Refer GCC/PCC Sub-Clause-14.1)

Tax Guidelines 2024 for Khorlochhu Hydro Power Limited (KHPL)

1. Introduction

This Tax Guideline is issued to Khorlochhu Hydro Power Limited (KHPL) responsible for construction and commissioning of Khorlochhu under Trashi Yangtse to facilitate exemption and refund process.

This Tax Guideline which provides special privileges and facilities in terms of speedy clearance of Projects consignments shall be used as the basis to accord tax/duty exemption to the Projects. However, it shall cease upon commercial operation of the Project.

2. Effective date of implementation

This Tax Guideline shall come into effect from the date of approval accorded by DRC to implement the Tax Guidelines.

3. Decentralization of Authority to issue exemption certificate

In order to facilitate speedy clearance of the Projects consignments, the Authority to issue exemption certificates is hereby decentralized to ***Regional Revenue and Customs Office (RRCO) S/Jongkhar where the project's major plant and machinery and direct inputs shall enter.*** Therefore, all exemption and refund process must be routed through RRCO S/Jongkhar.

4. Exemption without having to go through refund process

In the event KHPL has appointed principal contractors to execute the project, the same privileges extended to the Project shall be provided subject to the fulfillment of the conditions for exemption specified under this Tax Guidelines.

5. Administrative responsibility and accountability

It shall be the responsibility of KHPL to ensure that there is strict compliance to the provisions of this Tax Guideline and that the facilities and privileges granted under this Tax Guideline are not misused in any form. In case of non-compliance and misuse, KHPL shall be liable for fines and penalties including prosecutions as per the relevant Tax Acts of the Kingdom of Bhutan. The KHPL and its principal contractors shall furnish additional information and documents, if required for effective implementation of this Tax Guidelines.

6. General Preliminary

i. The privileges and facilities of availing STEC and IDEC directly at source, prior to import, shall be available only to the principal contractors of the KHPL. Therefore, any subcontractors further appointed by principal

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contractors of the Project shall not be eligible for such privileges and facilities.

ii. Sub-contractors engaged by the Registered/Authorized Contractors shall import and declare in the name of Registered/Authorized Contractors only. Refunds for such imports shall be made only in the name of registered contractors and on verification and endorsement by the KHPL.

iii. Unless otherwise exempted, any contractor, sub-contractor or consultants recruited in connection with the Project including the KHPL and its employees and the Project per se shall be liable for Sales Tax and Customs Duty as per the Sales Tax, Customs & Excise Act of the Kingdom of Bhutan, 2000 & amendments thereof.

iv. Unless otherwise exempted, any contractor, sub-contractor or consultants recruited in connection with the project including KHPL and its employees and the project per se shall be liable for Health Contribution and Income Tax as per the Income Tax Act of the Kingdom of Bhutan, 2001 & amendments thereof.

v. Unless otherwise specified herein, contractors, sub-contractors or consultants recruited in connection with the Project including KHPL will be liable for income tax in keeping with the Income Tax Act of the Kingdom of Bhutan. Employees working under these contractors, subcontractors or consultancy firms and the KHPL are also liable for health contribution and income tax in keeping with the Income Tax Act of the Kingdom of Bhutan.

vi. All contractors, sub-contractors or consultants engaged for the project including the KHPL shall be responsible for deducting and remitting Tax Deducted at Source (TDS) in keeping with the provisions of the Income Tax Act of the Kingdom of Bhutan, 2001 & amendments thereof.

vii. Unless otherwise specified herein, any contractors, subcontractors or consultant recruited in connection with the project including the KHPL and the project per se and their employees shall be liable for Sales Tax, Green Tax and Customs Duty as per the Sales Tax, Customs and Excise Act of the Kingdom of Bhutan 2000 and amendment thereof.

viii. No duty, surcharge or any other forms of levies including Sales Tax will be charged by RGoB on the water use for the generation of Power (except for Royalty Energy) and on the sale of power by the company within Bhutan or on its export to India.

ix. No taxes, duties etc. shall be levied by RGoB on the initial transfer of ownership of the Project from RGoB to the Joint Venture Company for execution on BOOT basis and its transfer back to RGoB after completion of the concession period as specified in the agreement of the project.

x. After the commencement of the commercial operation the Joint Venture Company, the KHPL shall be liable for all types of taxes in keeping with the taxation laws of the Bhutan. In this regard, the Project Authority shall inform in advance to the concerned RRCO with the copy to Department of the Revenue and Customs.

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xi. Any procurement made under tax/duty exemption basis shall be liable to tax/duty payment as per the Tax Act of the Kingdom of Bhutan, if disposed off in Bhutan.

xii. Unless there is a prior approval, exempted goods shall not be sold or re-exported.

xiii. Proper inventory of all exempted goods must be maintained by principal contractors and the KHPL, which shall be subject to post audit at any point of time.

xiv. The KHPL prior to the import or availing exemption shall submit list of the **principal contractors along with the copy of the contract agreement** to the Department and concerned RRCO.

xv. The KHPL should provide an updated list of all principal Contractors with projects to the concerned RRCOs and DRC from time to time. The KHPL and its principal contractors shall furnish any additional documents as and when requested by DRC, HQ and its Regional Offices.

7. Sales Tax and Customs Duty Exemption

Basis for exemptions

The article 7.3 of the Intergovernmental Agreement between the Royal Government of Bhutan and the Government of India concerning the development of the four Joint Venture project signed on 22nd April 2014 serves as the basis for this exemption on the following items as provided below.

"...Plants, Construction materials, equipment, machineries and services imported for direct use in the construction of the project."

The construction of the project shall broadly cover the construction of the dam & power house, surge shaft & pressure shaft, headrace tunnel and chambers.

The exemptions specified herein shall be based on the documents such as the detailed project report (DPR), Bill of Quantities (BOQ), contract agreement and other relevant documents signed regarding the JV projects, which shall be submitted accordingly to the concerned RRCO for verification.

What are exempted?

The exemption shall be provided on plant and machinery, equipment and construction materials forming direct inputs including the professional services for the construction of the project.

In addition to the above direct inputs, the dumpers, tippers, transit mixers and their spare parts shall also be eligible for exemption. However, the principal contractors, through concerned JV company, will submit the list and quantity of dumpers, tippers, transit mixers, machineries, equipment and their spare parts

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required for the whole project on an annual basis to the Department of Energy and the concerned Regional Revenue &Customs Office (RRCO) to avail tax/duty exemptions;

What are NOT exempted?
The following items shall NOT be eligible for Sales Tax and Customs Duty exemptions:

i. Vehicles;
ii. Accessories and spare parts
iii. HSD/POL;
iv. Fuels;
v. Printing and stationeries
vi. Office equipments and furniture
vii. Household items
viii. Hardware items and materials used for construction of residential and non-residential buildings such as office, and labor camps, shed for storage, workshops, etc;
ix. Sports items and equipment;
x. Import for canteens;
xi. Items personal and consumable in nature such as toiletries, groceries, food, helmets; gumboots, TV and other electronics, tools;
xii. Any other goods and services that are not direct inputs to the Project; and
xiii. Sales Tax shall not be exempted at the Point of Sales (PoS) on services provided by hotels & restaurants, Cable TV services etc. for all users of the services.
xiv. Sales Tax and Green Tax on HSD and POL either imported or purchased from sources inside Bhutan shall not be eligible for refund.
xv. Any other items that may be a direct input but are consumable in nature shall not be eligible for exemption.

8. Green Tax exemption

i. Vehicles imported, for direct use in the construction of the project, on a temporary or re-export basis shall not be subject to Green Tax.
ii. Vehicles (other than imported on a temporary or re-export basis and the HSD/POL consumed by both the contractors and Project Authority shall be not be eligible for exemption and refund thereof.

9. Excess materials

Excess materials are defined as those materials in excess (surplus) of what is actually used for the Project, irrespective of the quantities specified in the DPR/BOQ.

It shall be the responsibility of the KHPL to ensure that no excess materials are imported by its principal contractors.

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i. In case of excess import, the project shall declare all excess materials imported by its principal contractors to the concerned RRCO for payment of applicable Sales Tax and Customs Duty.
ii. Non-declaration, mis-declaration or concealment by the project authority shall be liable for fines and penalties including prosecutions as per the Sales Tax, Customs & Excise Act of the Kingdom of Bhutan, 2000 & amendments thereof and Income Tax Act of the Kingdom of Bhutan, 2001 & amendments thereof.
iii. Approval shall be obtained from the concerned RRCO prior to disposal/sale of the excess materials, if any.
iv. Should there be substantive reasons for the deviations in quantities from DPR/BOQ, a prior approval shall be sought in writing to continue to avail exemptions.

9. Requirement of license (s) and TPN by the principal contractors

The KHPL shall submit a list of principal contractors along with the copy of their licenses issued by the concerned agency to the concerned RRCOs. This is required in order to issue Taxpayer Number (TPN) (if the principal contractors are new) to facilitate imports of Project consignments.

10. General procedures for availing exemption for import of goods other than vehicles

i. All applications for exemptions must be submitted in advance, i.e. prior to import to the concerned RRCOs through **electronic and Customs Management System (eCMS).**
ii. All applications for exemptions shall be accompanied by forwarding letter signed by the authorized persons/liaison officers of the project.
iii. An explanatory note on the usage of items should be attached or uploaded along with the application for clear understanding of the items imported.
iv. The following documents should be submitted:
v. A copy of commercial invoice/bills;
vi. An import license (in ORIGINAL) issued by the concerned agency of RGoB in case of import from other than India; and

The concerned RRCO shall verify the application in terms of the eligibility and ineligibility of exemptions as per this Guideline and accord approval accordingly.

Exemption application for used or second hand goods shall be accompanied by special permit/clearance (in original) issued by the Ministry of Industry, Commerce & Employment or concerned organization as per the existing rule.

11. General Refund Procedures

i. In the event taxes/duties have been paid on exempted goods, the refund shall be allowed subject to fulfillment of the following refund conditions and procedures:



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ii. All applications for refund must be submitted to the concerned RRCO where taxes/duties have been originally paid.
iii. All applications for refund must be routed through the KHPL.
iv. The following documents should be submitted for the purpose of refund:
v. Refund Application Form;
vi. Money receipt of taxes/duties paid in ORIGINAL such as RGR money receipt or computer generated money receipt or advance adjustment voucher, where applicable;
vii. A copy of supplier's invoice such commercial invoice, excise invoice/bill;
viii. A copy of import declaration form, import bill etc. and
ix. Copy of STEC/IDEC issued by the issuing RRCO.
x. All applications for refund must be submitted within one year from the date of payment of taxes/duties failing which shall not be entertained.
xi. Refund in the form of "account payee cheque" shall be made directly to KHPL's bank account or to the principal contractor.
xii. (Note: Refunds not covered by this Tax Guideline shall be made in accordance with the existing refund manual/procedures.)

12. Import declaration & documents required

All imports made by the KHPL and its principal contractors, be it from India or 3rd countries, shall be declared at the point of importation/entry like any normal goods as per the existing Act and Rules in force.

All exemption prior to import shall be processed through ***eCMS and submit to the respective regional office for approval.***

Documents required for import from India

i. The following documents shall be submitted for the purpose of declaration for imports made from India.
ii. Covering/forwarding letter from the KHPL indicating that goods are meant for the projects.
iii. Invoices or bills.
iv. Excise invoice for direct procurement from a factory or authorized dealer.
v. Import permit from relevant agencies in case of restricted goods.
vi. Any other relevant documents.

Documents required from other than India

The following documents shall be submitted for the purpose of declaration for imports made from countries other than India:

i. Import License
ii. Pro-forma Invoice
iii. Commercial Invoice
iv. Packing list
v. Certificate of origin
vi. Bill of lading/Airway bill
vii. Marine/Air/Transit insurance policy

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viii. Freight bill
ix. Import permit from relevant agencies in case of restricted goods.

13. Temporary import of goods without payment of Sales Tax and Customs Duty

What are allowed to be imported on a temporary or re-export basis?

Those machines and equipment that are capital in nature (durable assets) and verifiable in terms of serial numbers such as registration number, make & model numbers and approved purposes/uses, etc. shall be allowed to be imported on a temporary basis without payment of Sales Tax and Customs Duty.

What are NOT allowed to be imported on a temporary or re-export basis?

The category of goods for civil, electrical, and plumbing works, and other materials used for installation or housing the machinery & equipment including spares, accessories, tools, kits, consumables and the like, office equipment and furniture, irrespective of the nature of the Project, shall NOT be allowed to be imported on a temporary basis without payment of Sales Tax and Customs Duty.

14. Applicability of Sales Tax/Customs Duty for used or second hand goods imported on a temporary or re-export basis

Import of all used or second hand goods shall be accompanied by a special permit (in original) issued by the relevant agency as per the existing rule. However, if such used or second hand goods are not eligible to be imported on a temporary basis as per Clause No 14. (b) above, it shall attract applicable Sales Tax and Customs Duty.

15. General Procedures for import of goods on a temporary or re-export basis

i. The authority to renew applications for temporary import is hereby decentralized to the concerned RRCO.
ii. All the application for temporary import and renewal thereof shall be submitted on time to the concerned RRCO.
iii. All applications for temporary import shall be routed through the project authority or its liaison officers, who shall ensure re-export of the goods to the country of origin.
iv. Sales Tax & Customs clearance shall be obtained from the concerned RRCO by the KHPL before releasing the security money of its contractors, if any, in order to ensure that goods on a temporary basis are re-exported to the country of origin. Security money shall be forfeited by the project authority in the event of non-compliance



v. All temporary import of machinery & equipment shall be cleared against a 'letter of undertaking' affixed with legal stamp, duly sealed, named and signed by the importer.

vi. The RRCO concerned shall accord approval of temporary import initially for a maximum period of 3 months in keeping with the provision of the Sales Tax, Customs & Excise Act, 2000. Thereafter, the renewal shall be made only for a maximum period of one year at a time, unlike in the past wherein renewal was granted until the completion of the Project. This is, in order to ensure timely monitoring of the goods imported on a temporary basis.

vii. All applications for temporary import of second hand or used machinery and equipment and the like shall be accompanied by a special permit (in original) issued by the Ministry of Industry, Commerce and Employment as per the existing rule.

viii. All the documents issued at the time of temporary import shall be produced at the customs check post at the time of re-export.

ix. Vehicles that are to be imported on a temporary basis shall be allowed subject to import permit/clearance from the Ministry of Industry, Commerce & Employment.

x. Vehicles imported for direct use in the construction of the project on a temporary or re-export basis shall not be subject to Sales Tax and Customs Duty.

xi. Vehicles other than the above import and HSD/POL consumed by both contractors and project authority shall be subject to Sales Tax, Green Tax and Customs Duty.

16. Procedures for disposal/sale of exempted goods

Goods imported for temporary use or on an exempt basis above shall not be disposed of or sold off without prior approval.

It shall be the responsibility of the KHPL to inform in writing to the DRC or its Regional Offices if any goods imported for temporary use or on an exempt basis are disposed of or sold off before or after the completion of the Project.

If approval is granted by DRC, HQ to dispose or sell such goods to a non-privileged person, it shall be liable for Sales Tax/Customs Duty/Green Tax, where applicable.

17. Others

i. All matters related to the Project must be routed through the office of the KHPL.

ii. All other procedures not covered by this Guideline shall be dealt with as per the existing Act and Rules thereto. In this regard, the KHPL and its contractors shall seek clarification, if any, in writing with the DRC, HQ.

iii. The KHPL and its contractors is requested to familiarize with the following documents for additional information:

iv. Sales Tax, Customs & Excise Act of the Kingdom of Bhutan, 2000 and amendments thereof.

Khorlochhu Hydro Power Ltd.

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v. Rules on the Sales Tax, Customs & Excise Act of the Kingdom of Bhutan, 2000 and amendments thereof.
vi. Customs Act of Bhutan 2017.
vii. Customs Rules and Regulations of Bhutan 2017.
viii. Income Tax Act of the Kingdom of Bhutan, 2001 and amendments thereof.
ix. Rules Income Tax Act of the Kingdom of Bhutan, 2001 and amendments thereof.
x. Bhutan Trade Classification Customs Tariff and Sales Tax Schedule 2022 and amendments thereof.

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SECTION -5

Forms & Procedures



SECTION-5: Forms & Procedures

Form - 1: Letter of Tender

{Refer ITB Clause-13.1, 14 & 21.2 (a)}

Name of Contract.....

To: (Name and Address of Employer)

Sir,

1.0 Having examined the Bid Documents, including Addenda Nos. *(Insert Numbers)*, the receipt of which is hereby acknowledged, we the undersigned, offer to construct and install such Works and remedy the defects therein in conformity with the Conditions of Contract, Specifications, Drawings, Bill of Quantities, Appendix to Tender and addenda (if any) for the sum of : ***(Prices to be left blank in Envelope-I)*** ……..... *(Insert amounts in words)* …… *(Amount in Figures),* as specified in the Appendix to Tender or such other sums as may be determined in accordance with the terms and conditions of the Contract.

Percentage of discount/rebate offered (if any) on aforesaid price: _____ % (***to be left blank in Envelope - I)***.

2.0 **Attachments to the Letter of Tender:**

In line with the requirement of the Bid Documents we enclose herewith the following Attachments to the Letter of Tender:

a. **Attachment 1:** Bid Security in the form of Bank Guarantee (in original) No.---------- dated---------- issued by ----------[Name and address of the Bank] for a sum of ..... *(Name of currency and amounts in words & figures)* valid up to and including [date 90 days after the period of bid validity].

b. **Attachment 2:** A power of attorney complying with the requirement of ITB Clause No. 5.1(a) indicating that the person(s) signing the bid have the authority to sign the bid and thus that the bid is binding upon us during the full period of its validity in accordance with the ITB Clause 17.

c. **Attachment 3:** The documentary evidence establishing in accordance with ITB Clause 3 that we are eligible to bid and in terms of ITB Clause 5.1(e). Our bid is strictly in conforming to the documents issued by the Employer. The updated qualification details have been furnished as per your format enclosed with the bid documents.

d. **Attachment 4**: Bidders Appreciation of the project.

It should include a report on the site inspection, awareness and understanding of all the principal, technical and logistic problems related to transportation and erection of the construction equipment, materials, availability of land, infrastructure, local taxes & laws and construction of works (ITB clause no. 8).

e. **Attachment-5**: Integrity Pact.

Integrity Pact Duly signed between Employer and the Bidder in accordance with Sub-Clause-3.3 of ITB.

f. **Attachment-6**: Undertaking by the parent/ holding company:

The commitment by the parent/holding company to sign a separate agreement with

Employer in compliance to ITB Clause 5.3(i) (if awarded the work).

g. **Attachment-7**: Joint Venture / Consortium Agreement:

A joint Venture / Consortium Agreement furnished in accordance with ITB Clause 6.2(v)

h. **Attachment-8**: Undertaking by the Sub-contractor(s):

The commitment by the Subcontractor to submit the Joint Deed of Undertaking in compliance to ITB Clause 5.4(ii) (if awarded the work).

i. **Attachment-9**: We agree and accept the names of approved Subcontractors/manufacturers/vendors mentioned in Attachement-8. We also propose additional Subcontractors/manufacturers/vendors, who meet the specific qualification criteria of the respective equipment/item mentioned in Attachment-9 and Attachment-10 and furnish the details of the name, nationality and documentary evidences in support of such additional Subcontractors/manufacturers/vendors meeting the specific qualifications. Further, we understand that the inclusion of additional Subcontractors/Manufacturers/Vendors in the list of approved Subcontractors/Manufacturers/Vendors shall be governed under PCC Clause no. 4.4 of Bid documents.

……..

 # (Any other attachment, if required shall be added here)

All other bidding documents issued by KHPL except Price Schedule not covered above duly stamped and signed on each page by the authorized signatory(ies) to the bid.

3.0 **Price Schedules:**

3.1 In line with the requirements of the Bid Documents, we enclose herewith the Price Schedule, duly filled-in as per your proforma.

@ Any other Schedule if required, shall be added here.

3.2 We are aware that the Bill of Quantities do not generally give a full description of the work to be performed under each item and we shall be deemed to have read the Technical Specifications and other Bid Documents and Drawings to ascertain the full scope of work included in each item while filling-in rates and prices. We agree that entered rates and prices shall be deemed to include for the full scope as aforesaid, including applicable taxes, duties, royalties, octroi, cess & levies etc. and overhead and profit.

3.3 We declare that as specified in General Condition of Contract (Clause13.7 & 13.8) and Particular Condition of Contract (Sub Clause 13.7 &13.8), the Price Schedule shall be subject to adjustment. Our prices are inclusive of all the applicable taxes, duties, levies, cess, royalties and octroi for the performance of the Contract.

3.4 We confirm that we have examined and are aware of the conditions and adequacy of infrastructural facilities, Construction Equipment and related spares, services lines, partially completed works etc. to be handed over by the Employer for performance of Contract.

3.5 We confirm that we shall get registered with the concerned Sales Tax/Department of Trade & Industry, RGoB, in the country where the project is located. We also confirm that we shall produce the Tax Payer Number (TPN) issued by concerned authorities in Bhutan to the Engineer, before receiving the first payment under the Contract, if the work is awarded to us.

3.6 We confirm that no Sales Tax/Entry tax/Levies in any form shall be payable by you for the bought out items which are dispatched directly by us/our Assignee to the project site. However, you will issue requisite Sales Tax declaration forms in respect of such bought

out items, on production of documentary evidence of registration with the concerned Sales Tax Authorities.

3.7 We undertake, if our bid is accepted, to commence the work immediately upon your Letter of Acceptance to us, and to achieve Completion of Works within the time stated in the Bid Documents.

3.8 If our bid is accepted, we undertake to provide a Performance Security in the form and amounts, and within the time specified in the Bid Documents.

3.9 We agree to abide by this bid for a period of 180 days from the date of opening of Technical bid as stipulated in the Bid Documents, and it shall remain binding upon us and may be accepted by you at any time before the expiration of that period.

3.10 Until a formal Contract is prepared and executed between us, this bid, together with your written acceptance thereof in the form of your Letter of Acceptance shall constitute a binding contract between us.

3.11 We understand that you are not bound to accept the lowest or any bid you may receive. We acknowledge the right of the Employer to reject our Bid without assigning any reason or otherwise and hereby waive our right to challenge the same on any account whatsoever.

3.12 All information provided in my/our Bid and attachments thereof is true and correct and all documents copies of which are attached with our Bid as attachments are true copies of their respective originals.

3.13 I/We hereby certify that we have not been banned/ de-listed/ black listed/ debarred from business by the Employer or any Government institution or public sector enterprise or any government, Central or State or any statutory authority in India or Bhutan during last 03 (three) years on grounds of corrupt/fraudulent practices.

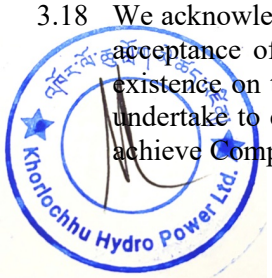
3.14 I/We hereby declare that only the persons or firms interested in this proposal as principals are named in our Bid and that no other person or firm or company other than those mentioned in our Bid has any interest in this bid submission or in the Contract to be entered into and in good faith, without collusion or fraud, if our Bid is accepted as evidenced by issue of Letter of Acceptance to us.

3.15 We understand that you may annul the bidding process and reject all bids or accept or reject any of the bids at any time and that you are neither bound to accept any bid that you may receive nor to invite the Bidders to bid for Works, without incurring any liability to all or any of the Bidders.

3.16 We believe that we continue to satisfy the eligibility criteria and meet(s) the requirements as specified in the Bid Documents and are qualified to submit a Bid in accordance therewith.

3.17 We have studied all the Bid Documents carefully and also surveyed the Works Site and understood all local and site conditions affecting the execution of the Works. We understand that except to the extent as expressly set forth in the Contract, we shall have no claim, right or title arising out of any documents or information provided to us by the Employer or in respect of any matter arising out of or concerning or relating to the bidding process including the award of Works to the selected bidder.

3.18 We acknowledge and confirm that upon issue of Letter of Acceptance to us consequent to acceptance of our Bid, a binding contract for execution of the Works shall come into existence on the terms set forth in our Bid together with your Letter of Acceptance. We undertake to commence the work upon issue of your said Letter of Acceptance, and to achieve Completion within the time stipulated in the Bid Documents.



3.19 We agree and understand that the Bid is subject to the provisions of the Bid Documents. In no case, we shall have any claim or right of whatsoever nature if the Works is not awarded to us or our Bid is not opened.

3.20 We, hereby, declare that only the persons or firms interested in this proposal as principals are named here and that no other persons or firms other than those mentioned herein have any interest in this proposal or in the Contract to be entered into, if the award is made on us, that this proposal is made without any connection with any other person, firm or party likewise submitting a proposal is in all respects for and in good faith, without corrupt/fraudulent/collusive/coercive practice.

Dated this.....day of.....20….

Thanking you, we remain,

Yours faithfully,

(Signature)

(Printed Name)

(Designation)

(Common Seal)

Date :

Place :

Business Address:

Country of Incorporation:

(State or Province to be indicated)

Name & Address of the Principal Officer:



Attachment – 1:

{Refer ITB Clause-18}

(To be executed on non-judicial Stamp papers/Legal Stamp of Appropriate value)

BID SECURITY FORM

Bank Guarantee

Date:_____

(Name of Contract)

To: (Name and address of Employer)

WHEREAS (name of Bidder) (hereinafter called "the Bidder") has submitted its Bid dated (date of bid) for the performance of the above-named Contract (hereinafter called "the Bid")

KNOW ALL PERSONS by these present that WE (name of Bank) of (address of bank) (hereinafter called "the Bank"), are bound unto (name of Employer) (hereinafter called "the Employer") for the sum of: (amount), for which payment well and truly to be made to the said Employer, the Bank binds itself, its successors and assigns by these presents.

THE CONDITIONS of this obligation are as follows:

1. If the Bidder withdraws its Bid during the period of bid validity specified by the Bidder in the Letter of Tender, or adopts corrupt or collusive or coercive or fraudulent practices or default under Integrity Pact.
2. If the Bidder, having been notified of the acceptance of its Bid by the Employer during the period of bid validity.
   a) If the Bidder, fails or refuses to sign the Contract Agreement when required, or
   b) If the Bidder, fails or refuses to submit the performance security in accordance with the bid documents.

WE undertake to pay to the Employer up to the above amount upon receipt of its first written demand, without the Employer having to substantiate its demand, provided that in its demand the Employer will mention that the amount claimed by it is due, owing to the occurrence of one or both of the two above-named CONDITIONS, and specifying the occurred condition or conditions.

This guarantee will remain in force up to and including (date 90 days after the period of bid validity), and any demand in respect thereof must reach the Bank not later than the above date.

For and on behalf of the Bank

_____

in the capacity of

_____

Common Seal of the Bank



Instructions for execution of Bank Guarantee for Bid Security

1. *Bank Guarantee for Earnest Money Deposit should be executed on non-judicial Stamp papers/Legal Stamp of requisite value in accordance with the stamp Act if applicable to that particular state of Indian Union/country of executing Bank, where executed.*
2. *The executing officers of the Bank Guarantee for Earnest Money/Bid Security shall clearly indicate in (block letters) his name, designation, Power of Attorney No. / Signing Power No. as well as telephone/ fax numbers with full correspondence address of the issuing Guarantee etc.*
3. *Each page of the Bank guarantee for Earnest Money Deposit shall be duly signed/initialed by the executing officers and the last page shall be signed in full, indicating the particulars as aforesaid (sub-para 2) under the seal of the Bank.*
4. *Stamp paper shall be purchased in the name of Bank issuing the Bank Guarantee, after the date of 'Notice Inviting Tender', not more than six (6) months prior to execution/ issuance of the Bank Guarantee. The name of the purchaser should appear at the back side of stamp paper in the Vendors Stamp. The issuing Bank shall be requested independently for verification/confirmation of the Bank Guarantee issued, non-confirmation of which may lead to rejection of 'Bid Security'.*
5. *Bank Guarantee for Bid security in original shall be submitted along with the Bid. However, the issuing Bank shall submit an unstamped duplicate copy of Bank Guarantee directly by registered post (A.D.) to the Employer (authority inviting tenders) with a forwarding letter.*



Attachment – 2

{Refer ITB Sub- Clause-5.1 a)}

POWER OF ATTORNEY

(On non-judicial Stamp papers/Legal Stamp of Appropriate value)

KNOW ALL MEN BY THESE PRESENTS THAT WE M/S ……., A COMPANY ORGANISED AND EXISTING UNDER THE LAWS OF (NAME OF COUNTRY ……..……) AND HAVING ITS REGISTERED/PRINCIPAL OFFICE /PLACE OF BUSINESS AT……..…REPRESENTED BY (NAME OF PERSONS) (THE "EXECUTANT") DO HEREBY NOMINATE, CONSTITUTE, AUTHORIZE AND APPOINT MR. […….*Name of Attorney*……] , SON OF [……..…], RESIDENT OF [……] AND PRESENTLY EMPLOYED WITH], A COMPANY/ CORPORATION ORGANISED AND EXISTING UNDER THE LAWS OF ……. (NAME OF THE COUNTRY) AND HAVING ITS REGISTERED OFFICE/PRINCIPAL PLACE OF BUSINESS AT ……..……. AS OUR TRUE AND LAWFUL ATTORNEY (THE "ATTORNEY") TO DO IN OUR NAME AND ON OUR BEHALF ALL OR ANY OF THE FOLLOWING ACTS, DEEDS AND THINGS IN CONNECTION WITH OR IN RESPECT OF OR RELATING TO THE NOTICE INVITING TENDER NO. …… DATED ……. (THE "NIT") ISSUED BY _____, A COMPANY ORGANISED AND EXISTING UNDER THE LAWS OF _____ AND HAVING ITS REGISTERED OFFICE (UNDER THE COMPANIES ACT, _____) (AT _____ (THE "EMPLOYER") FOR THE EXECUTION, CONSTRUCTION AND DEVELOPMENT OF THE WORKS DESCRIBED IN THE NOTICE INVITING TENDER (NIT) (THE "WORKS") THAT IS TO SAY:

1. TO PREPARE, OFFER, SIGN, SUBMIT AND DELIVER TO THE EMPLOYER THE EXECUTANT'S BID FOR THE WORKS PURSUANT TO THE NIT (THE "BID") INCLUDING TO MAKE, SIGN (JV/Consortium Agreement), SUBMIT, DELIVER, EXECUTE, AND ACCEPT ALL DOCUMENTS, INCLUDING JOINT VENTURE/CONSORTIUM AGREEMENT, INFORMATION, APPLICATIONS AND OTHER WRITINGS NECESSARY FOR OR INCIDENTAL TO THE SIGNING, SUBMISSION AND DELIVERY OF THE BID TO THE EMPLOYER;
2. TO NEGOTIATE, ENTER IN AND ALL, SIGN AND EXECUTE, ACCEPT AND DELIVER THE CONTRACTS UNDERTAKINGS, ACCEPTANCES AND OTHER WRITINGS CONSEQUENT UPON ACCEPTANCE OF THE EXECUTANT'S BID;
3. PARTICIPATE IN BIDDERS' AND OTHER CONFERENCES AND PROVIDE ALL INFORMATION REQUIRED BY THE EMPLOYER AND TO FURNISH/SEEK CLARIFICATIONS ARISING OUT OF OR RELATING TO THE NIT AND, UPON AWARD OF THE CONTRACT CONSEQUENT TO THE ACCEPTANCE OF THE EXECUTANT'S BID BY THE EMPLOYER;
4. TO REPRESENT AND ACT ON BEHALF OF THE EXECUTANT IN RESPECT OF ALL MATTERS BEFORE THE EMPLOYER RELATING TO THE EXECUTANT TO BID AND UPON THE ACCEPTANCE OF THE EXECUTANT'S BID BY THE EMPLOYER INCLUDING THE RESULTANT CONTRACT ON SUCH THE ACCEPTANCE OF THE EXECUTANT'S BID (THE "CONTRACT") IN RESPECT OF ALL MATTERS RELATING TO OR ARISING OUT OF OR CONCERNING THE CONTRACT AND TO GENERALLY DEAL WITH THE EMPLOYER ON BEHALF OF THE EXECUTANT IN ALL MATTERS ARISING OUT OF OR IN CONNECTION WITH OR RELATING TO OR ARISING OUT

OF THE EXECUTANT'S BID. THE NIT AND THE CONTRACT IN THE EVENT OF ACCEPTANCE OF THE EXECUTANT'S BID BY THE EMPLOYER;

5. AND GENERALLY TO DO ANY AND ALL OTHER AND FURTHER ACTS, DEEDS AND THINGS WHICH ARE NECESSARY FOR OR INCIDENTAL TO OR DEEMED APPROPRIATE FOR MORE EFFECTUAL EXERCISE OF THE POWERS HEREBY CONFERRED.

AND We, the Executant above named do hereby agree and undertake to ratify and confirm and do hereby ratify and confirm all acts, deeds and things lawfully done or caused to be done by our said Attorney pursuant to and in exercise of the powers hereby conferred and all acts, deeds and things done or caused to be done by our said Attorney pursuant hereto shall always be deemed to be the acts, deeds and things done by the Company itself.

IN WITNESS WHEREOF, THIS POWER OF ATTORNEY ON THIS [……] DAY OF [……..], [20…..]……. ……. has been executed under the common seal of the Company, at ----------(name of place).

For [Name of the Executant]

By ……
(Name of Officer)

Title

WITNESSES

1.

2.

Notes:

i) The mode of execution of the Power of Attorney should be in accordance with the procedure, if any, laid down by the applicable law and the charter documents of the executant(s) and when it is so required, the same should be under common seal affixed in accordance with the required procedure.

ii) The Bidder should submit for verification the extract of the charter documents and documents such as a resolution of its Board of Director/ power of attorney in favour of the person executing this Power of Attorney for delegation of power hereunder on behalf of the Bidder.



Attachment – 3
(Refer ITB Sub-clause 5.1.e)

FORM OF DECLARATION

A Declaration in Respect of the Submitted Bid Documents/ Proposals

Subject: In respect of execution of Main Electro-Mechanical Package (KEM-1) of Khorlochhu Hydropower Project; it is declared without any reservation whatsoever that:

1) the submitted Techno-Commercial/Price Bid proposals are without any deviations and are strictly in conformity with the documents issued by the Employer.
2) in case any deviations are noticed which might have crept inadvertently, such deviations without reservation of any kind are automatically deemed to have been withdrawn by us.
3) We are familiar with all the requirements of the Contract and have not been influenced by any statement or promise of any person of the Employer.
4) We are experienced and competent Bidder to perform the Contract to the satisfaction of Employer and are familiar with all general and special laws, acts, ordinances, rules and regulations of the Government of Bhutan that may affect the work, its performance or personnel employed therein.
5) We hereby authorize the Employer to seek reference from our bankers for its financial position and undertake to abide by all labour welfare legislations.
6) We have not been banned/ de-listed/ blacklisted/ debarred from business by the Employer or any Government institution or public sector enterprise or any government, Central or State or any statutory authority in India or Bhutan as on the time of bid submission deadline on grounds of corrupt/fraudulent practices in terms of ITB 3.2.
7) We do not and shall not appoint **local agents** in Bhutan in terms of ITB 3.4
8) The above statement submitted by us is true and correct to our best knowledge.

Date : (Signature)

Place: (Printed Name)

(Designation)

(Common Seal)

N.B: WITHOUT THIS CERTIFICATE BID IS LIABLE TO BE REJECTED.



Attachment – 4

{Refer ITB Clause-8.0}

BIDDER'S APPRECIATION OF THE PROJECT

It should include a report on the site inspection, awareness and understanding of all the principal, technical and logistic problems related to transportation and installation/handling of the construction equipment/ materials, availability of land, infrastructure, local taxes & laws and construction of works (ITB Clause No. 8).

Date : (Signature)

Place : (Printed Name)

(Designation)

(Common Seal)

Attachment – 5

(Refer ITB Clauses/Sub-Clauses – 3.3, 13.2, 18.6,35)

(To be executed on plain paper at the time of submission of bid affixed with legal stamp and on legal paper of appropriate value by successful bidder (Contractor) prior to signing of Contract Agreement)

INTEGRITY PACT

1. General:

Whereas, **Mr. Sonam Rixin, General Manager, Contracts & Procurement Division**, representing the Khorlochhu Hydro Power Limited (KHPL), herein after referred to as the Employer on one part, and *(Name of person)* representing the (*Name of Bidder or his/her authorized representative, with power of attorney*) representing (*Name of firm*) as the "Bidder" on the other part hereby execute this agreement as follows:

This agreement should be a part of the standard bidding document, which shall be signed by both the parties at the time of purchase of bidding documents and submitted along with the tender document. The head of the employing agency/or his authorized representative should be the signing authority. For the bidders, the bidder himself or his authorized representative must sign the Integrity Pact (IP). If the winning bidder had not signed during the submission of the bid, the tender shall be cancelled.

2. Objectives:

Whereas, the Employer and the Bidder agree to enter into this agreement, hereinafter referred to as IP, to avoid all forms of corruption or deceptive practice by following a system that is fair, transparent and free from any influence/unprejudiced dealings in the **bidding process**[1] and **contract administration**[2], with a view to:

2.1. Enabling the Employer to obtain the desired contract at a reasonable and competitive price in conformity to the defined specifications of the works, goods and services; and

2.2. Enabling bidders to abstain from bribing or any corrupt practice in order to secure the contract by providing assurance to them that their competitors will also refrain from bribing and other corrupt practices.

3. Scope:

The validity of this IP shall cover the bidding process and contract administration period.

4. Commitments of the Employer

The Employer commits itself to the following:

4.1. The Employer hereby undertakes that no official of the Employer, connected directly or indirectly with the contract, will demand, take a promise for or accept, directly or through intermediaries, any bribe, consideration, gift, reward, favour or any material or immaterial benefit or any other advantage from the Bidder, either for themselves or for any person, organization or third party related to the contract in exchange for an advantage in the bidding process and contract administration.

---

[1] Bidding process, for the purpose of this IP, shall mean the procedures covering tendering process starting from bid preparation, bid submission, bid processing, and bid evaluation.

[2] Contract administration, for the purpose of this IP, shall mean contract award, contract implementation, un-authorized sub-contracting and contract handing/taking over.



4.2. The Employer further confirms that its officials shall not favor any prospective bidder in any form that could afford an undue advantage to that particular bidder during the bidding process and contract administration and will treat all Bidders alike.

4.3. Officials of the Employer, who may have observed or noticed or have reasonable suspicion shall report to the head of the employing agency or an appropriate government office any violation or attempted violation of clause 4.1 and 4.2.

4.4. Following report on violation of clauses 4.1 and 4.2 by official (s), through any source, necessary disciplinary proceedings, or any other action as deemed fit, including criminal proceedings shall be initiated by the Employer and such a person shall be debarred from further dealings related to the bidding process and contract administration.

5. Commitments of Bidders:

The Bidder commits himself to take all measures necessary to prevent corrupt practices, unfair means and illegal activities during any stage of the bidding process and contract administration in order to secure the contract or in furtherance to secure it and in particular commits himself to the following:

5.1. The Bidder will not offer, directly or through intermediaries, any bribe, gift, consideration, reward, favour, any material or immaterial benefit or other advantage, commission, fees, brokerage or inducement to any official of the Employer, connected directly or indirectly with the bidding process and contract administration, or to any person, organization or third party related to the contract in exchange for any advantage in the bidding process and contract administration.

5.2. The Bidder will not collude with other parties interested in the contract to manipulate in whatsoever form or manner, the bidding process and contract administration.

5.3. If the bidder(s) have observed or noticed or have reasonable suspicion that the provisions of the IP have been violated by the procuring agency or other bidders, the bidder shall report such violations to the head of the procuring agency.

6. Sanctions for Violation:

The breach of any aforesaid provisions shall result in administrative charges or penal actions as per the relevant rules and laws.

6.1. The breach of the IP or commission of any offense (forgery, providing false information, mis-representation, providing false/fake documents, bid rigging, bid steering or coercion) by the Bidder, or any one employed by him, or acting on his/her behalf (whether with or without the knowledge of the Bidder), shall be dealt with as per the terms and conditions of the contract and other provisions of the relevant laws, including De-barment Rules.

6.2. The breach of the IP or commission of any offence by the officials of the procuring agency shall be dealt with as per the rules and laws of the land in vogue.

7. Monitoring and Administration:

7.1. The respective procuring agency shall be responsible for administration and monitoring of the IP as per the relevant laws.

7.2. The bidder shall have the right to appeal as per the arbitration mechanism contained in the relevant rules.

We hereby declare that we have read and understood the clauses of this agreement and shall abide by it.

The parties hereby sign this Integrity Pact at _____ on_____



Affix Legal Stamp

EMPLOYER

CID: 1 1 1 0 7 0 0 6 6 7 7

BIDDER/REPRESENTATIVE

CID:

Witness: _____

Name:

CID: 1 1 6 0 5 0 0 0 2 0 3

Witness: _____

Name:

CID:



Attachment – 6

{Refer ITB Sub- Clause-5.3 i)}

UNDERTAKING BY THE PARENT/HOLDING COMPANY

(On letter head of Parent / Holding Company)

No: …… Date:……..

To,
The General Manager,
Contracts and Procurement Division,
Khorlochhu Hydro Power Limited,
Doksum New Township, Trashiyangste, BHUTAN

Sub: Invitation for Bidding for Package…… of Khorlochhu Hydropower Project

Dear Sir(s),

We, M/s …….. (Name of the Parent/Holding Company) having registered office at …… (Address of the Parent/Holding Company) ……. do hereby undertake that in case work of Construction of Package - ……, …… H.P. Project is awarded to M/s …… (Name of the Bidder), who is participating in your subject Tender as a Sole Bidder, which is our subsidiary company, we on our strength/strength of …… (name of group company(ies)) under our control shall provide the full support for technical and financial requirements for the work "……..." (the scope of work of subsidiary company) and we shall be responsible for successful completion of the job covered under the scope of M/s ……. (Name of Subsidiary company).

In case the Bidder, M/s …… (Name of Subsidiary company) gets qualified/techno commercially responsive and awarded the work, we do hereby undertake;

(i) to enter into a separate agreement with the Employer as per the Employer's approved format included in the Bid documents.

(ii) to furnish an additional performance Bank guarantee of value equivalent to five (5%) percent of the Accepted Contract Amount or the portion of work (where the Subsidiary Company is a Partner/Consortium Bidder) as the case may be, if the subsidiary Company is qualified on the strength of Parent Company or group company(ies) under the control of Parent/Holding Company.

We do hereby also confirm that we are not participating either as a sole Bidder or as a subcontractor against the above Invitation.

Yours faithfully,

For & on behalf of M/s. …….
(Name & Address of the Parent/holding Company)

(Office Seal)
Station:
Date:

Notes:

- *This letter of authorization should be on the letterhead of the Parent/Holding Company and should be signed by a person competent and having the Power of Attorney to bind the Parent/Holding Company. Power of Attorney in favour of this person to do so be enclosed with this Letter of Undertaking.*

Attachment – 7

{Refer ITB Sub- Clause-5.4 (i)}

UNDERTAKING FROM SUBCONTRACTOR

No: …… Date:……..

To,
The General Manager,
Contracts and Procurement Division,
Khorlochhu Hydro Power Limited,
Doksum New Township, Trashiyangste, BHUTAN

Dear Sir(s),

We, M/s …….. (Name of the Parent/Holding Company) having registered office at …… (Address of the Parent/Holding Company) ……. do hereby undertake that in case work ……(Name of the work) is awarded to M/s …… (Name of the Bidder), we shall execute the work of "_____" (the components of the work for which the Bidder has proposed to associate the subcontractor/manufacturer), as subcontractor/manufacturer to M/s ……..(Name of the Bidder) and we shall submit a joint Deed of Undertaking as per approved format of Employer included in the Bid Document and also agree to provide an additional Performance Bank Guarantee of 5% (five percent) of value of sub-let portion of works in addition to normal Performance Bank Guarantee, as per the format included in the Bid Document.

We do hereby also confirm that we are not participating either as a sole Bidder or as a partner of Joint Venture/consortium Bidder against the above Notice Inviting Tender.

Yours faithfully,

For & on behalf of M/s. ……..
(Name & Address of the Subcontractor/Manufacturer)
(Office Seal)

Station:

Date:

Notes:

i) This letter of authorization should be on the letterhead of the subcontractor and should be signed by a person competent and having the Power of attorney to bind the subcontractor. Power of Attorney in favour of this person to do so be enclosed with this Letter of Undertaking.

ii) In case a bidder has been qualified for any of the work on the credential of a proposed sub-contractor/manufacturer of the bidder, he shall be required to submit a joint deed of undertaking (as per agreed format) from the proposed subcontractor/manufacturer and bidder for joint and several responsibility of execution of Work sub-contracted to the subcontractor.

❖ *Strike out the form, if not applicable by the bidder.*



Attachment – 8

{Refer ITB Sub- Clause-4.4}

LIST OF APPROVED SUBCONTRACTORS/MANUFACTURERS/VENDORS

The following Subcontractors/Manufacturers/Sub-vendors are approved for carrying out the supply/work of items of the facilities indicated. Where more than one Subcontractors/Manufacturers/Sub-Vendors are listed, the Contractor is free to choose between them.

Sl. No.	Description Of Equipment	Acceptable Make / Sub-Vendor
1.0	**Mechanical**	
1.1	Main Inlet Valve (Spherical Valve)	• Andritz • Voith • L&T • BHEL
1.2	Butterfly Valve	• Andritz • Voith • L&T • BHEL
1.3	Oil Pumping Unit	• HYDAC • Rexroth
1.4	Lube Oil System	• HYDAC • Rexroth
1.5	Crane	• FAFECO • Mukand • WMI Kone Cranes • Anupam Industries • Eddy Cranes
1.6	Pumps	• Kirloskar • Worthington • KSB Pumps • WILO • Grundfos
1.7	Hoist	• FAFECO • Mukand • WMI Kone Cranes • Anupam Industries • Eddy Cranes
1.8	Compressor	• ELGI • Atlas Copco • Ingersoll Rand
1.9	**HVAC**	
i)	Duct able /Non duct able Split AC	• Blue Star • Carrier • LG
ii)	Centrifugal Fan / Axial Fan	• Patel Airflow • Alstom (GEC) • Flakt • Nadi • Kruger. • Nicotra

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Sl. No.	Description Of Equipment	Acceptable Make / Sub-Vendor
		• Greenheck • Comefri
iii)	Cooling Coil	• Jaypee • Zeco • McCann • Edge Tech
iv)	Expansion Tank	• ABB • Voltas • Blue Star • Sintex
v)	Exhaust Fan (propeller type) with Motor	• Kruger • Alstom (GEC) • Khaitan Fans • Patel Air Flow • Nicotra • Dustven
1.10	Fire Protection System	
i)	Hydrant Valve	• Shah Bhogilal • Sukan • HD Fire • Newage • Winco
ii)	Fire Hose with Coupling	• Newage • CRC • Shah Bhogilal
iii)	Water Monitor	• Shah Bhogilal • Newage • HD Fire • Winco
iv)	Branch Pipe, Nozzle & Coupling	• Shah Bhogilal • Sukan • Newage • Winco
v)	Deluge Valve / Alarm check Valve along with associated trims and instruments (UL/FM approved)	• HD Fire • Tyco
vi)	Sprinkler Nozzle & QBD (UL/FM approved)	• HD Fire • Tyco
vii)	Fire Extinguishers	• Safex • Zenith • Nitin • Kanadia
viii)	Hose Box	• Shah Bhogilal • Newage • Safex
1.11	Structural Steel and Plates	• SAIL • TATA • JINDAL • ESSAR • RINL

Sl. No.	Description Of Equipment	Acceptable Make / Sub-Vendor
1.12	MS ERW Pipes	• Maharashtra Seamless • Tata/SAIL • JINDAL • Surya Roshni
1.13	MS SAW Pipes	• PSL India • Ratnamani • Welspun • SAIL • Mann Industries • Lalit Pipes • JCO Gas Pipes
1.14	Seamless Pipes CS and low alloy steel	• Maharashtra Seamless • ISMT • BHEL • Mahalaxmi Seamless
1.15	SS Pipes (Seamless and ERW)	• Apex tubes • Choksi tubes • Heavy Metal and tubes • Ratnamani • REMI Edelsthal • Sumitomo • Sanyo
1.16	Fittings	• True Forge • Tube products • Siddharth and Gautam • Pipe fit
1.17	Diesel Engine	• KOEL • Greaves • Cummins
1.18	Plate Heat Exchanger	• Kelvion • Alfa Laval • GEA • Tranter
1.19	Tube Heat exchanger	•
1.20	Gate/Globe/Check Valves (Upto 600 NB)	• SWIMS • Fouress • KSB • L&T • Leader • KBL
1.21	Rubber Expansion Joint	• CORI • SRM Exoflex • Eagle Burgmann
2.0	**Electrical**	
2.1	Generator Transformer	• ABB (Hitachi) • Siemens • GE • TELK
2.2	AUTO Synchroniser	• WOODWARD • ABB

Sl. No.	Description Of Equipment	Acceptable Make / Sub-Vendor
		• GE • SIEMENS
2.3	Power Transformer	• ABB(Hitachi) • Siemens • GE • TELK
2.4	Reactor	• ABB(Hitachi) • Siemens • GE • TELK
2.5	LV Distribution Transformer (Oil Filled)	• Hitachi • ABB • Voltamp • Kirloskar Electric • CGL • Bharat Bijlee • Raychem
2.6	LV Distribution Transformer (Dry Type)	• Raychem • Hitachi • ABB • Voltamp • Kirloskar Electric • CGL • Bharat Bijlee
2.7	Gas Insulated substation (GIS)	• Toshiba • Hitachi • Siemens • GE • Hyosung Corporation, S. Korea
2.8	Lightning Arrestor	• ABB • LAMCO • CGL • OBLUM • Seimens
2.9	Isolator (Outdoor)	• Siemens • S&S Power Switchgear Ltd. • ABB (Hitachi) • CGL
2.10	Current Transformer 420 kV (Outdoor)	• GE • ABB (Hitachi) • Seimens • CGL • Mehru Elec.
2.11	Capacitor Voltage Transformer 420 kV (Outdoor)	• GE • ABB (Hitachi) • Seimens • CGL • Mehru Elec.
2.12	MV Switchgear	• ABB • Hitachi

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Sl. No.	Description Of Equipment	Acceptable Make / Sub-Vendor
		• SIEMENS • Schneider Electric • CG Power
2.13	LV Switchgear / Distribution Board	• L&T • SIEMENS • Schneider Electric • ABB (Hitachi) • C&S Electric
2.14	IPBD	• C&S Electric • Reep industries • Powergear
2.15	Batteries	• EXIDE • Amara Raja • HBL • Hoppecke Batteries GmbH & Co.
2.16	Battery Charger / DC System	• EXIDE • Amara Raja • HBL • Vertiv (Emerson) • Chloride Power • Delta Corporation • Masstech Controls Pvt. Limited
2.17	UPS System	• Vertiv (Emerson) • DB Power Electronics • Dubas • Hitachi-Hirel • Schneider Electric
2.18	UPS Battery	• EXIDE • Amara Raja • HBL • Hoppecke Batteries GmbH & Co.
2.19	Battery Discharge	• S R Narkhede • Engg Pvt. Ltd • AMP Control Equipment Pvt. Ltd • Iresco Electricals Pvt. Ltd • Vertiv (Earlier Emerson) • Mass-Tech Controls Pvt Ltd
2.20	NIFPS for Transformer	• CTR Manufacturing • Tectonicus • Vendre Sales
2.21	Lighting DB's	• Philips • Bajaj Electricals • CGL • GE • Wipro • L&T • MDS • Havells • C&S
2.22	Lighting Fixture	• Philips

Sl. No.	Description Of Equipment	Acceptable Make / Sub-Vendor
		• Bajaj Electricals • CGL • GE • Wipro • Havells • Pyrotech
2.23	Aviation lighting	• Binay Opto Electronics • Lumen(Microtech) • Avaids Technovators. • Insta Power
2.24	High Mast (Lighting Towers)	• Bajaj Electricals • CGL • Wipro • Phillips
2.25	400 kV / 220 kV / 132 kV / 66 kV Cables	• Universal cables • Sterlite • KEI • LS Cables • Brugg Kabel • Furukawa • Sudkabel
2.26	MV Power Cables	• Finolex • Universal Cables • Nicco Corporation • Polycab • KEC International • Cable Corporation • KEI Cables • Torrent • Dynamic Cables • APAR Industries • Havells • Gemscab Industries • Sterlite
2.27	LV Power Cables	• Finolex • Universal Cables • Nicco Corporation • Polycab • KEC/RPG • Cable Corporation • KEI Cables • Torrent • Ravin Cables • Gemscab Industries • APAR Industries • Gupta Cables. • Dynamic Cables
2.28	LV Motors	• ABB • CGL • SIEMENS • Kirloskar Electric



Sl. No.	Description Of Equipment	Acceptable Make / Sub-Vendor
		• BHEL • Marathon Motors • Bharat Bijlee
2.29	MV/LV - CT/PT (Cast Resin)	• Pragati Electricals • AE • Kappa • Schneider • CGL / Indicoil • Vidyut Udyog • Electrical Control & Systems • Translec engineers • RECO • Maxwel – Gilbert • Huphen Fabricator • Huphen Electromech • Indcoil
2.30	Meters	• ABB • SCHNEIDER • SIEMENS • Secure Meters • AE, RISHABH and MECO • Automatic Electric • Meco • Rishab Instruments • M.B. Controls • Motwani
2.31	MFM	• AE • ABB • MECO • RISHABH • SCHNEIDER • SIEMENS • Satec • Secure • Lauritz & Knudsen
2.32	PQMS	• SEL • Hitachi • SIEMENS • GE
2.33	PMU	• SEL • ABB • Hitachi • SIEMENS
2.34	Revenue Meters (KWH/TVM)	• Secure & Lauritz & Knudsen • L&T • Genius
2.35	Protection Relays	• ABB • SIEMENS • GE • Alstom

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Sl. No.	Description Of Equipment	Acceptable Make / Sub-Vendor
		• Schneider • SEL • Andritz (HIPASE)
2.36	3 Phase Relay Test Kit	• Omicron (CMC356+)
2.37	Protection Relays (LV System)	• ABB • SIEMENS • GE -Alstom • Schneider
2.38	Variable Frequency Drive / Soft Starter	• SIEMENS • ABB-Hitachi • Schneider • Rockwell
2.39	Cable Trays & Accessories	• Indiana • Patni • Reliance • Sadhna • Sterlite
2.40	Cable Termination / Jointing Kits	• Raychem • 3M • Denson • Brugg Kabel. • NKT • Nexans • Pfisterer • LS Cables • GALA Shrink Fi • Nexans - Euromold brand
2.41	Emergency DG set and Auxiliaries	• Sterling Generator • Caterpillar Power • Cummins Power • Wartsila India Ltd. • Powerica • Kirloskar • Sudhir Gen set • Jackson
2.42	Alternator for DG set	• STAMFORD • Leroy somer.
2.43	Panel Enclosures and Local Push Button Stations	• Rittal • Pyrotech
2.44	Fire Alarm & Detection System	• GE • NOTFIRE • SIEMENS • New Fire • Technofab • Unitech • Honeywell • Minimax • Tyco • Vijay fire • AND

Sl. No.	Description Of Equipment	Acceptable Make / Sub-Vendor
		• Algodex • Reliance fire • Kidde
2.45	EPBAX System	• Avaya • Cisco • Alcatel • SIEMENS • Erricson
2.46	CCTV	• Bosch • Acti • Axis and Panasonic • Hanwah
2.47	PA	• Haritasa • ABS • Philips • Bosch • SIEMENS • Gai-Tronics • Honeywell • ME-Call Services
2.48	FOTE	• SIEMENS • Dipali Automation • Microscan • Ninesec • Orient
2.49	GATEWAY	• GE • ABB • SIEMENS • Cisco
2.50	Disturbance Recorder	• GE • ABB • SIEMENS • Kalketech • SEL
3.0	**Instrumentation & Control System**	
3.1	Programmable Logic Controllers/SCADA	• SIEMENS • Rockwell Automation India Pvt ltd • Mitsubishi electric India Pvt. Ltd. • GE • HONEYWELL
3.2	Operator / Engineering station	• IBM • HP • DELL
3.3	Printers	• XEROX • Epson • TVSE (dot matrix) • HP • CANON-

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Sl. No.	Description Of Equipment	Acceptable Make / Sub-Vendor
3.4	Master Clock System	• Sertel Electronics Pvt. Ltd • Masibus Process Instruments Pvt. Ltd. • Mainberg
3.5	Vibration and Air Gap Monitoring System	• Bentley Nevada • Schenk Avery Ltd. • Metrix Instrument Co • Vibrometer • Bruel & Kjae • Meggitt • IFM • TE Connectivity
3.6	Pressure Gauges/ Differential Pressure / Temperature Gauges	• Wika • Hydac EDS1700 • H Guru • Gauges Bourdon (India) Ltd • AN Instruments • Baumer Technologies India Pvt. Ltd
3.7	Level Gauges	• Wika • IFM • Gauges Bourdon (India) Ltd. • B.K. Equipment Pvt. Ltd. • Magnetrol Industrial inc.
3.8	Sight Flow Indicator	• Hydropneumatics • Chemtrols Samil • Eureka
3.9	Pressure/ Differential Pressure Switches	• IFM • Wika • Baumer Technologies India Pvt. Ltd. • Switzer Instruments Ltd. • Gauges Bourdon (India) Ltd.,
3.10	Level Switch Float Type	• Wika • Levcon Instruments Pvt. Ltd. • Magnetrol • Pune Techtrol Pvt. Ltd. • SBEM Pvt. Ltd
3.11	Capacitance Level Switch	• IFM • Nivo Controls Pvt. Ltd • Pune Techtrol Pvt. Ltd. • SBEM Pvt. Ltd
3.12	Speed/Proximity Switches	• IFM Electronic • BALLUFF • Turck India Automation Pvt.Ltd. • Ashoka Electronics



Sl. No.	Description Of Equipment	Acceptable Make / Sub-Vendor
3.13	Flow Switch	• Honeywell Automation India Ltd. • Wika • IFM • Magnetrol Industrial Inc • Switzer Instrument Co
3.14	Variable Area Rotameter	• Brook Instrument India Pvt. Ltd. • Emerson Process Management (India) Pvt. Ltd. • EUREKA
3.15	Magnetic Flow Meter	• IFM • Endress & Hauser • Yokogawa • Foxboro (Schneider electric) Emerson- • EMERSON
3.16	Temperature Elements (Sensors-RTD, T/C) with Thermowell	• Pyro Electric Instruments Pvt. Ltd. • Detriv Instrumentation & Electronics • Tempsens • Pyrotech Controls (I) Pvt. Ltd. • Techno Instruments Pvt Ltd • TE Connectivity
3.17	Transmitters (Flow, Level, Pressure, Temperature & Differential Pressure)	• Emerson Process Management • Endress+Hauser (India) Pvt Ltd • Honeywell Automation India Ltd.
3.18	Guided Wave Radar Level Transmitter (Non-contact type)	• Endress+Hauser (India) Pvt. Ltd. • Emerson • Siemens Ltd. • Vega • IFM
3.19	Ultrasonic Level Transmitter	• Endress+Hauser (India) Pvt. Ltd. • Nivo Controls Pvt. Ltd. • Emerson Process Management • Siemens • ABB • Dwyer Instruments
3.20	Ultrasonic Flowmeter	• Siemens • IFM • Emerson • Endress+Hauser (India) Pvt. Ltd. • Danfoss A/S • Bronkhorst • IFM • Dwyer Instruments
3.21	Impulse Tubes & Fittings	• Parker Hannifin • Swagelock



Sl. No.	Description Of Equipment	Acceptable Make / Sub-Vendor
3.22	Control Valve	• Forbes Marshall • CCI • Koso • KSB Mil Controls • Fisher
3.23	Air Filter Regulators	• Placka Instruments & Controls FESTO • Shavo Norgreen India Pvt. Ltd.
3.24	Solenoid Valves Along With Tubing Fitting	• Asco (India) Ltd Festo • Rotex Automation Ltd. • HERION NORGREN • Swagelock • Tameson
3.25	Limit Switches	• BALLUFF • Masibus Process Instruments Pvt. Ltd. • Omron Automation Private Limited • OSNA Electronics Pvt. Ltd • SIEMENS
3.26	Position Transmitter	• Endress & Hauser • SIEMENS • Emerson • Rotork
3.27	Junction Boxes	• Rittal • HENSEL electric India Pvt. Ltd • Baliga
3.28	Control Panels	• Rittal • Pyrotech Controls (I) Pvt. Ltd. • Industrial & Commercial Enterprises • Positronics Pvt. Ltd. • Modutec
3.29	Push Button, Selector Switch, Lamp	• SIEMENS • Telemecanique • TECNIK • ABB
3.30	Terminals	• Connectwell • Phoenix Contacts (India) Pvt. Ltd. • WEIDMULLER
3.31	Power Supply Units	• Cosel Asia Ltd. • Connectwell • Phoenix Contacts (India) Pvt. Ltd. • Weidmuller
3.32	Interposing Relays	• Omron Automation Pvt. Ltd. • Finder • ABB • Sçhrack
3.33	Signal Isolator	• MTL • P&F • Phoenix Contacts

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Sl. No.	Description Of Equipment	Acceptable Make / Sub-Vendor
3.34	Panel Digital Indicators	• YOKOGAWA • MTL • Redlion • Selec
3.35	I&C Cables	• Polycab • Lapp • KEI • Havells
3.36	Fiber Optic Cables	• Finolex Cables Ltd. • Lapp Yndia • Rosenberger
3.37	Micro LED Video Wall and its Converter 19" 42U RACK	• Delta • Planar(Leyard) • Pyrotech • Barco • Rittal • President • Valrack • Delta • Barco • Pyrotech
3.38	Firewall	• Juniper • Cisco • Checkpoint • Palo Alto
3.39	LIU (Fiber Optic)	• CommScope • Raychem • AFS • Phoenix Contact
3.40	Ethernet Switch	• Cisco • Juniper • Ruggedcom-Siemens
3.41	Configuration Laptop	• HP • DELL
3.42	Antivirus	• VMware Carbon Black • ESCAN • McAFee



Attachment – 9

{Refer ITB Sub- Clause-4.4}

NAME OF PROPOSED SUBCONTRACTORS/VENDORS PROPOSED BY THE BIDDER

Bidders can also suggest alternate names for inclusion into the list fulfilling the specific qualification criteria listed against those items. Bidder is also required to certify regarding financial soundness, technical capability of proposed subcontractors/manufacturers/sub-vendors. Bidders are free to propose more than one for each item.

Sl. No.	Description of Equipment	Proposed Make / Sub-Vendor



Attachment – 10

(Refer Sub-clause 4.4 of GCC/PCC)

NAME OF PROPOSED SUBCONTRACTORS FOR ERECTION, TESTING AND COMMISSIONING

Bidders shall propose the list of Subcontractors for erection, testing and commissioning of the works if applicable fulfilling the specific qualification criteria. Bidder is also required to certify regarding the financial soundness, technical capability of proposed Subcontractors. Bidders are free to propose more than one.

Sl. No.	Items of Works	Name of Subcontractors / Vendors and Nationality	Specific Qualification Criteria
1.	Erection, Testing and Commissioning Works		The Sub-contractor: i) Should have executed similar work of comparable size earlier during last ten (15) years. ii) Works performed should have been successfully commissioned in at least at three installations. iii) Engineers and Technicians must have at least fifteen (15) years of experience in comparable sizes. Documentary evidence & satisfactory performance report along with the complete details of the company profile be furnished.

Form - 2: Form of Contract Agreement

(Refer Sub-clause 1.6 of GCC/PCC)

(To be executed on legal paper of appropriate value)

AGREEMENT

This agreement is made on _____ day of _____ Two Thousand ------- between the _____, registered and existing under the Laws of _____ and having its registered Office at _____ (hereinafter referred to as the "Employer" which expression shall unless repugnant to the context or meaning thereof include its successors and assigns) of the one part and M/s _____ registered under the _____ Act and having its principal / registered office at _____(herein after called "the Contractor" which expression shall unless repugnant to the context or meaning thereof, include its successors and permitted assigns) of the other part.

WHEREAS the Employer is desirous that the Works known as _____should be executed by the Contractor, and has accepted a Tender by the Contractor for the execution and completion of such Works and the remedying of any defects therein at the cost of ------- (Rupees----------).

NOW THIS AGREEMENT WITNESSETH as follows:

1. In this Agreement, words and expressions shall have the same meanings as are respectively assigned to them in the Conditions of Contract hereinafter referred to.
2. The following documents shall be deemed to form and be read and construed as part of this Agreement, viz:
   i) the Letter of Acceptance;
   ii) the Letter of Tender;
   iii) the Particular Conditions of the Contract and the Appendix to Tender;
   iv) the General Conditions of the Contract (FIDIC), First Edition 1999;
   v) the Technical Specifications;
   vi) the Tender Drawings;
   vii) the Price Schedules;
   viii) Data Sheets;
   ix) Information for Bidders;
   x) any other documents forming part of the Contract.
3. In consideration of the payments to be made by the Employer to the Contractor as hereinafter mentioned, the Contractor hereby covenants with the Employer to execute and complete the Works and remedy the defects therein in conformity in all respect in accordance with the provisions of the Contract.
4. The Employer hereby covenants to pay the Contractor in consideration of the execution and completion of the works and remedying of defects therein the Contract Price or such other sum as may become payable under the provisions of the Contract at the time and in the manner prescribed by the Contract.

In Witness whereof the parties hereto have caused this Agreement to be executed the day and year first before written, at ---------- (name of place).



The Common Seal of _____

was hereunto affixed in the presence of:

For and on behalf of the Contractor

Signature----------

(Designation)----------

Place:

Witnessed by:

1. Name & Address

2. Name & Address

For and on behalf of Employer

Signature----------

(Designation)----------

Place:

Witnessed by:

1. Name & Address

2. Name & Address



Form – 3: Performance Security Form

(Refer Sub-clause 34 of ITB)

(To be submitted by the Contractor)

Bank Guarantee

(To be stamped in accordance with Stamp Act if any, of the Country of the Issuing Bank)

Bank Guarantee No.....
Date.....

To,

[Employer's Name & Address]

Dear Sirs,

In consideration of the ... *[Employer's Name]*..... (hereinafter referred to as the 'Employer' which expression shall unless repugnant to the context or meaning thereof, include its successors, administrators and assigns) having awarded to M/s .....*[Contractor's Name]*..... with its Registered/Head Office at ..... (hereinafter referred to as the 'Contractor', which expression shall unless repugnant to the context or meaning thereof, include its successors, administrators, executors and assigns), a Contract by issue of Employer's Letter of Acceptance No..... dated..... and the same having been acknowledged by the Contractor, for ----------[Contract sum in figures and words] for ……*[Name of the work]* and the Contractor having agreed to provide a Contract Performance Guarantee for the faithful performance of the entire Contract equivalent to .....(*).....of the said value of the aforesaid work under the Contract to the Employer.

We.....*[Name & Address of the Bank]*.....having its Head Office at ..... (hereinafter referred to as the 'Bank', which expression shall, unless repugnant to the context or meaning thereof, include its successors, administrators, executors and assigns) do hereby guarantee and undertake to pay the Employer, on demand any and all monies payable by the Contractor to the extent of .....(*)..... as aforesaid at any time upto .....(@)..... *[days/month/year]* without any demur, reservation, contest, recourse or protest and/or without any reference to the Contractor. Any such demand made by the Employer on the Bank shall be conclusive and binding notwithstanding any difference between the Employer and the Contractor or any dispute pending before any Court, Tribunal, Arbitrator or any other authority. The Bank undertakes not to revoke this guarantee during its currency without previous consent of the Employer and further agrees that the guarantees herein contained shall continue to be enforceable till the Employer discharges this guarantee or till ……(+)…….. *[days/month/year]* whichever is earlier.

(**)

The Employer shall have the fullest liberty, without affecting in any way the liability of the Bank under this guarantee, from time to time to extend the time for performance of the Contract by the Contractor. The Employer shall have the fullest liberty, without affecting this guarantee, to postpone from time to time the exercise of any powers vested in them or of any right which they might have against the Contractor, and to exercise the same at any time in any manner, and either to enforce or to forbear to enforce any covenants, contained or implied, in the Contract between the Employer and the Contractor or any other course or remedy or security available to the Employer. The Bank shall not be released of its obligations under these presents by any exercise by the Employer of its liberty with reference to the matters aforesaid or any of them or by reason of any other act or forbearance or other acts of omission

or commission on the part of the Employer or any other indulgence shown by the Employer or by any other matter or thing whatsoever which under the law would, but for this provision have the effect of relieving the Bank.

The Bank also agrees that the Employer at its option shall be entitled to enforce this Guarantee against the Bank as a principal debtor, in the first instance without proceeding against the Contractor and notwithstanding any security or other guarantee the Employer may have in relation to the Contractor's liabilities.

i) Our liability under this Bank Guarantee shall not exceed _____(*)_____.

ii) This Bank Guarantee shall be valid up to _____(+)_____.

iii) We are liable to pay the guaranteed amount or any part thereof under this Bank Guarantee only and only if Employer serves upon Bank a written claim or demand on or before (@)_____

Dated this .....day of .....20_.....at.....

WITNESS

(Signature)..... (Signature).....

(Name)…….. (Name).....

…….. …….

(Official Address) (Designation with Bank Stamp)/with staff Authority no.

Complete Address of the Bank with Tele-Fax

Notes:

1. *(*) This sum shall be ten percent (5%) of the Contract Price denominated in the types and proportions of currencies.*

   (@) This date will be Ninety (90) days beyond the Defects Notification period as specified in the Contract.

   (+) This date will be 90 days beyond the Defect Notification Period.

   (**) Employer may also present any of his demands at the counters of the …… (Name and branch of the Bank in Bhutan)…….for further relay to us. (To be inserted in case of a foreign currency bank guarantee issued by an overseas bank outside Bhutan)

2. *Bank Guarantee should be executed on appropriate stamp paper of requisite value, such stamp paper should be purchased in the name of Issuing Bank, not more than six (6) months prior to execution / issuance of Bank Guarantee. The name of the purchaser should appear at the back side of stamp paper in the Vendors Stamp. Bank guarantee should contain rubber stamp of the authorized signatory of the bank indicating the name, designation and signature/ power of attorney number as well as telephone/ fax numbers with full correspondence address of the Bank.*

3. *Bank Guarantee is required to be submitted directly to the Employer by the issuing bank (on behalf of Contractor) under registered post (A.D). The Contractor can submit an advance copy of Bank Guarantee to the Engineer.*

4. *The issuing bank shall write the name of bank's controlling branch/ Head Office along with contact details like telephone/ fax and full correspondence address in order to get the confirmation of BG from that branch/ Head office, if so required.*

Form - 3: Bank Guarantee for Performance Security

(Refer Sub-Clause 34 of ITB)

(To be submitted by the Contractor)

Bank Guarantee

(To be stamped in accordance with Stamp Act if any, of the Country of the Issuing Bank)

Bank Guarantee No..... Date.....

To,

[Employer's Name & Address]

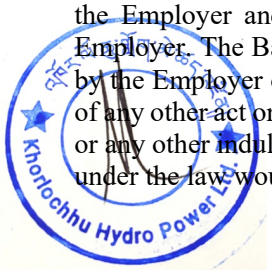
Dear Sirs,

In consideration of the ... *[Employer's Name]*..... (hereinafter referred to as the 'Employer' which expression shall unless repugnant to the context or meaning thereof, include its successors, administrators and assigns) having awarded to M/s .....*[Contractor's Name]*..... with its Registered/Head Office at ..... (hereinafter referred to as the 'Contractor', which expression shall unless repugnant to the context or meaning thereof, include its successors, administrators, executors and assigns), a Contract by issue of Employer's Letter of Acceptance No..... dated..... and the same having been acknowledged by the Contractor, for ----------[Contract sum in figures and words] for ……*[Name of the work]* and the Contractor having agreed to provide a Contract Performance Guarantee for the faithful performance of the entire Contract equivalent to .....(*).....of the said value of the aforesaid work under the Contract to the Employer.

We .....*[Name & Address of the Bank]*.....having its Head Office at.....(hereinafter referred to as the 'Bank', which expression shall, unless repugnant to the context or meaning thereof, include its successors, administrators, executors and assigns) do hereby guarantee and undertake to pay the Employer, on demand any and all monies payable by the Contractor to the extent of .....(*)..... as aforesaid at any time upto .....(@)..... *[days/month/year]* without any demur, reservation, contest, recourse or protest and/or without any reference to the Contractor. Any such demand made by the Employer on the Bank shall be conclusive and binding notwithstanding any difference between the Employer and the Contractor or any dispute pending before any Court, Tribunal, Arbitrator or any other authority. The Bank undertakes not to revoke this guarantee during its currency without previous consent of the Employer and further agrees that the guarantees herein contained shall continue to be enforceable till the Employer discharges this guarantee or till ……(+)…….. *[days/month/year]* whichever is earlier.

(**)

The Employer shall have the fullest liberty, without affecting in any way the liability of the Bank under this guarantee, from time to time to extend the time for performance of the Contract by the Contractor. The Employer shall have the fullest liberty, without affecting this guarantee, to postpone from time to time the exercise of any powers vested in them or of any right which they might have against the Contractor, and to exercise the same at any time in any manner, and either to enforce or to forbear to enforce any covenants, contained or implied, in the Contract between the Employer and the Contractor or any other course or remedy or security available to the Employer. The Bank shall not be released of its obligations under these presents by any exercise by the Employer of its liberty with reference to the matters aforesaid or any of them or by reason of any other act or forbearance or other acts of omission or commission on the part of the Employer or any other indulgence shown by the Employer or by any other matter or thing whatsoever which under the law would, but for this provision have the effect of relieving the Bank.



The Bank also agrees that the Employer at its option shall be entitled to enforce this Guarantee against the Bank as a principal debtor, in the first instance without proceeding against the Contractor and notwithstanding any security or other guarantee the Employer may have in relation to the Contractor's liabilities.

i) Our liability under this Bank Guarantee shall not exceed _____(*)_____.

ii) This Bank Guarantee shall be valid up to _____(+)_____.

iii) We are liable to pay the guaranteed amount or any part thereof under this Bank Guarantee only and only if Employer serves upon Bank a written claim or demand on or before (@)_____

Dated this .....day of .....20_.....at.....

WITNESS

(Signature)..... (Signature).....

(Name) (Name).....

(Official Address) (Designation with Bank Stamp)/with staff Authority no.

Complete Address of the Bank with Tele-Fax

Notes :

1. *(*) This sum shall be ten percent (10%) of the Contract Price denominated in the types and proportions of currencies.*

   (@) This date will be Ninety (90) days beyond the Defects Notification period as specified in the Contract.

   (+) This date will be 90 days beyond the Defect Notification Period.

   (**) Employer may also present any of his demands at the counters of the .....(Name and branch of the Bank in Bhutan)..... for further relay to us. (To be inserted in case of a foreign currency bank guarantee issued by an overseas bank outside Bhutan)

1. *Bank Guarantee should be executed on appropriate stamp paper of requisite value, such stamp paper should be purchased in the name of Issuing Bank, not more than six (6) months prior to execution / issuance of Bank Guarantee. The name of the purchaser should appear at the back side of stamp paper in the Vendors Stamp. Bank guarantee should contain rubber stamp of the authorized signatory of the bank indicating the name, designation and signature/ power of attorney number as well as telephone/ fax numbers with full correspondence address of the Bank.*
2. *The issuing bank shall write the name of bank's controlling branch/ Head Office along with contact details like telephone/ fax and full correspondence address in order to get the confirmation of BG from that branch/ Head office, if so required.*



Form - 4: Bank Guarantee for Advance Payment

(Refer Sub-clause 14.2 of GCC/PCC)

(To be stamped in accordance with Stamp Act if any, of the Country of the Issuing Bank)

Bank Guarantee No..... Date.....

To,

[Employer's Name & Address]

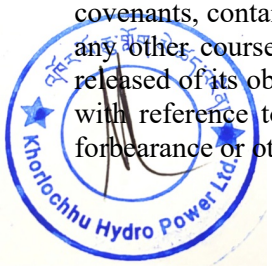
Dear Sir,

In consideration of the *[Employer's Name]*..... (hereinafter referred to as the 'Employer', which expression shall, unless repugnant to the context or meaning thereof include its successors, administrators and assigns) having awarded to M/s.....*[Contractor's Name]*..... with its Registered/Head Office at ..... (hereinafter referred to as the 'Contractor' which expression shall unless repugnant to the context or meaning thereof, include its successors, administrators, executors and assigns), a Contract, by issue of Employer's Letter of Acceptance No. ..... dated ..... and the same having been acknowledged by the Contractor, resulting into a Contract bearing No. .....dated.....valued at..... ……for .....*[Name of Contract*] .....(hereinafter called the 'Contract') and the Employer having agreed to make an advance payment to the Contractor for performance of the above Contract amounting ..... (in words and figures) as an Advance against Bank Guarantee to be furnished by the Contractor.

We.....*[Name and address of the Bank]*..... having its Head Office at ..... (hereinafter referred to as the 'Bank', which expression shall, unless repugnant to the context or meaning thereof, include its successors, administrators, executors and assigns) do hereby guarantee and undertake to pay the Employer, immediately on demand any or, all monies payable by the Contractor to the extent of .....*[advance amount]*..... as aforesaid at any time up to .....(@)..... without any demur, reservation, contest, recourse or protest and/ or without any reference to the Contractor. Any such demand made by the Employer on the Bank shall be conclusive and binding notwithstanding any difference between the Employer and the Contractor or any dispute pending before any Court, Tribunal, Arbitrator or any other authority. We agree that the guarantee herein contained shall be irrevocable and shall continue to be enforceable till the Employer discharges this guarantee. This guarantee may be progressively reduced by amount repaid by the Contractor.

(**)

The Employer shall have the fullest liberty without affecting in any way the liability of the Bank under this guarantee, from time to time to vary the advance or to extend the time for performance of the Contract by the Contractor. The Employer shall have the fullest liberty without affecting this guarantee, to postpone from time to time the exercise of any powers vested in them or of any right which they might have against the Contractor, and to exercise the same at any time in any manner, and either to enforce or to forbear to enforce any covenants, contained or implied, in the Contract between the Employer and the Contractor or any other course or remedy or security available to the Employer. The Bank shall not be released of its obligations under these presents by any exercise by the Employer of its liberty with reference to the matters aforesaid or any of them or by reason of any other act or forbearance or other acts of omission or commission on the part of the Employer or any other



indulgence shown by the Employer or by any other matter or thing whatsoever which under law would but for this provision have the effect of relieving the Bank.

The Bank also agrees that the Employer at its option shall be entitled to enforce this Guarantee against the Bank as a principal debtor, in the first instance without proceeding against the Contractor and notwithstanding any security or other guarantee that the Employer may have in relation to the Contractor's liabilities.

Notwithstanding anything contained herein:

i) Our liability under this Bank Guarantee shall not exceed_____.

ii) This Bank Guarantee shall be valid up to _____@_____.

iii) We are liable to pay the guaranteed amount or any part thereof under this Bank Guarantee only and only if Employer serve upon Bank a written claim or demand on or before (@)_____

Dated this ..... day of .....(month).....(year)..... at ..... .

WITNESS

(Signature)..... (Signature).....

(Name)…… (Name).....

....

(Official Address) (Designation with Bank Stamp)/Staff Authority No.

Complete Address of the Bank with Tele-Fax

Notes:

1. *(@) This date shall be ninety (90) days beyond the date of completion of delivery of goods at site as detailed in accordance with GCC Sub-Clause 8.3 [Programme].*

   (**) Employer may also present any of his demands at the counters of the..... (Name and branch of the Bank in Bhutan)..... for further relay to us. (To be inserted in case of a foreign currency bank guarantee issued by an overseas bank outside Bhutan)

2. *Bank Guarantee should be executed on appropriate stamp paper of requisite value, such stamp paper should be purchased in the name of Issuing Bank, not more than six (6) months prior to execution / issuance of Bank Guarantee. The name of the purchaser should appear at the back side of stamp paper in the Vendors Stamp. Bank guarantee should contain rubber stamp of the authorized signatory of the bank indicating the name, designation and signature/ power of attorney number as well as telephone/ fax numbers with full correspondence address of the Bank.*

3. *Bank Guarantee is required to be submitted directly to the Employer by the issuing bank (on behalf of Contractor) under registered post (A.D.). The Contractor can submit an advance copy of Bank Guarantee to the Engineer.*

4. *The issuing bank shall write the name of bank's controlling branch/ Head Office along with contact details like telephone/ fax and full correspondence address in order to get the confirmation of BG from that branch/ Head office, if so required.*



Form – 5: Form of Taking-Over Certificate

Date:_____

[*Name of Contract]*

To: *[Name and address of Contractor]*

Dear Sir,

Pursuant to General **Conditions of the Contract, Clause- 10 *[Taking-Over Certificate]*** of the Conditions of the Contract entered into between yourselves and the Employer dated *[date]*, relating to the *[brief description of the Works],* following part(s) of the Works was (were) complete on the date specified below, and that, in accordance with the terms of the Contract, the Employer hereby takes over the said part(s) of the Works, together with the responsibility for care and custody and the risk of loss thereof on the date mentioned below;

1. Description of the Works or part thereof: *[description]*
2. Date of Completion: *[date]*

However, you are required to complete the outstanding items listed in the attachment hereto as soon as practicable.

This letter does not relieve you of your obligation to complete the execution of the Works in accordance with the Contract nor of your obligations during the Defects Notification Period.

Very truly yours,

Title

(Engineer)



Form – 6: Bank Guarantee Form for Release/Payment of Retention Money

(Refer Sub-clause 14.9 of GCC/PCC)

(To be stamped in accordance with Stamp Act if any, of the Country of the Issuing Bank)

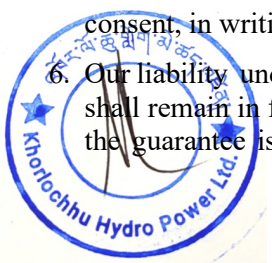
Bank Guarantee No..... Date.....

To,

[Employer's Name & Address]

1. We.....*[Name and address of the Bank]* ..... having our Registered/Head Office at ..... (hereinafter referred to as the 'Bank', which expression shall, unless repugnant to the context or meaning thereof, include its successors, administrators, executors and assigns) do hereby undertake and agree to indemnify and keep indemnified the……..*[Employer's Name]* ……..... (hereinafter referred to as "the Employer " which expression shall, unless repugnant to the subject or context, include its administrators, successors and assigns), to the extent of .....*[amount]*..... on behalf of M/s.....*[Contractor's Name]*..... with its Registered/Head Office at..... (hereinafter referred to as "the Contractor) in lieu of an equal cash amount of Retention Money deposited by the Contractor and/or deducted by the Employer from the bills of the Contractor and which the Employer has agreed to substitute with a bank guarantee as hereunder, under the provisions of Contract No. .....Dated. ….....which the Contractor has entered into with the Employer in connection with the construction of.....…. (*Name of Work*) at a total cost of..... (*Contract Sum*) (hereinafter called the ` Contract').
2. We, the Bank also do hereby agree to pay unequivocally and unconditionally within 48 hours on demand, in writing, from the Employer, of any amount up to and not exceeding .....*[amount]*..... to the Employer for any purpose or cause or on any account whatsoever under the provisions of the Contract in which respect the decision of the Employer shall be final and binding on us.

   (**)
3. Provided that it shall not be necessary for the Employer to proceed against the Contractor before proceeding against us and the guarantee herein contained shall be enforceable against us, notwithstanding any security which the Employer may have obtained or obtain from the Contractor shall, at the time when proceedings are taken against us as hereunder, be outstanding or unrealised.
4. We, the Bank, further agree that this guarantee shall be valid and binding on us up to and including .....(@).....and shall not be terminable by notice or any change in the constitution of the said Bank or the Contractor or by any other reasons whatsoever and our liability hereunder shall not be impaired or discharged by any extension of time or variations made, given, conceded, or agreed with or without our knowledge or consent, by or between the parties to the Contract.
5. We also undertake not to revoke this guarantee during its currency except with the previous consent, in writing, of the Employer.
6. Our liability under this guarantee is restricted to ……..*[amount]*..... Our guarantee shall remain in force until .....(@) .....unless a suit or action to enforce a claim under the guarantee is filed against us within 90 days from that date, all your rights under this



guarantee shall be forfeited and we shall be relieved and discharged from all liabilities thereunder:

In the presence of

Witness For and on behalf of the Bank

..... Bank's common seal

Dated this.....day of .....(month)……..(year)

The above Guarantee is accepted by the Employer

For and on behalf of the Employer

Signature.....

Name and designation.....

Name of Project/Unit.....

Date.....

Notes:

1. *(@) This date will be Ninety (90) days beyond the Defects Notification period as specified in the Contract.*

   (**) Employer may also present any of his demands at the counters of the .....(Name and branch of the Bank in Bhutan)..... for further relay to us. (To be inserted in case of a foreign currency bank guarantee issued by an overseas bank outside Bhutan)

2. *Bank Guarantee should be executed on appropriate stamp paper of requisite value, such stamp paper should be purchased in the name of Issuing Bank, not more than six (6) months prior to execution / issuance of Bank Guarantee. The name of the purchaser should appear at the back side of stamp paper in the Vendors Stamp. Bank guarantee should contain rubber stamp of the authorized signatory of the bank indicating the name, designation and signature/ power of attorney number as well as telephone/ fax numbers with full correspondence address of the Bank.*

3. *Bank Guarantee is required to be submitted directly to the Employer by the issuing bank (on behalf of Contractor) under registered post (A.D.). The Contractor can submit an advance copy of Bank Guarantee to the Engineer.*

4. *The issuing bank shall write the name of bank's controlling branch/ Head Office along with contact details like telephone/ fax and full correspondence address in order to get the confirmation of BG from that branch/ Head office, if so required.*



Form – 7: Hindrance Register

(Refer sub clause 4.21 of GCC/PCC)

Name of Project: ----------

1. Name of Work: ----------

2. Agreement No.: ----------

3. Executing Agency: ----------

Sl. No.	Nature/ Reason of Hindrance	Item /Component of works which could not be executed on account of this Hindrance	Date of start of Hindrance	Date of removal of Hindrance	Hindrances due to Interface Activities	Overlapping Period (if any)	Details of Idle Equipment & Manpower	Net Hindrances in days	Signature of Engineer	Signature of Contractor	Remarks
1	2	3	4	5	6	7	8	9	10	11	12



Form – 8: Dispute Adjudication Agreement

(Refer Sub-Clause 20.2 of GCC)

[for each member of a three-person DAB]

(*To be executed on non-judicial Stamp papers/Legal Stamp of appropriate value)*

Name and address of the Employer:

Name and address of Contractor :

Name and address of Member:

Whereas the Employer and the Contractor have entered into the Contract and desire jointly to appoint the Member to act as one of the three persons who are jointly called the "DAB" *{and desire the Member to act as chairman of the DAB}*.

The Employer, Contractor and Member jointly agree as follows:

1. The conditions of this Dispute Adjudication Agreement comprise the "General Conditions of Dispute Adjudication Agreement"., which is appended to the General Conditions of the "Conditions of Contract for Construction" First Edition 1999 published by the Federation Internationale des Ingenieurs-Conseils (FIDIC), and the following provisions. In these provisions, which include amendments and additions to the General Conditions of Dispute Adjudication Agreement, words and expressions shall have the same meanings as are assigned to them in the General Conditions of Dispute Adjudication Agreement.
2. *[Details of amendments to the General Conditions of Dispute Adjudication Agreement, if any, For example:*

   In the procedural rules annexed to the General Conditions of Dispute Adjudication Agreement, Rule _ is deleted and replaced by: "……"].
3. In accordance with Clause 6 of the General Conditions of Dispute Adjudication Agreement, the member shall be paid as follows:

   A retainer fee of, BTN/INR----------/- per calendar month, plus a daily fee of BTN/INR---------- per day.
4. In consideration of these fees and other payments to be made by the Employer and the Contractor in accordance with Clause 6 of the General Conditions of Dispute Adjudication Agreement, the Member undertakes to serve, as described in this Dispute Adjudication Agreement, as one of the three persons who are jointly to act as the DAB.
5. The Employer and the Contractor jointly and severally undertake to pay the Member, in consideration of the carrying out of these services, in accordance with Clause 6 of the General Conditions of Dispute Adjudication Agreement.
6. This Dispute Adjudication Agreement shall be governed by the law of ------

SIGNED BY: for and on behalf of the Employer in the presence of	SIGNED BY: for and on behalf of the Contractor in the presence of	SIGNED BY: Member in the presence of

Witness:	Witness:	Witness
Name:	Name:	Name:
Address:	Address:	Address:
Date:	Date:	Date:

[A brief description or name of dispute to be added]*



Form - 9: Parent/Holding Company Agreement

(Refer ITB Sub - Clause 5.3 ii)

(To be executed on non-judicial Stamp papers/Legal Stamp of Appropriate value)

(For sole Bidder)

THIS AGREEMENT IS MADE on this the …….. day of …… between the ……., a company incorporated under the laws of Bhutan and having its Registered and Corporate Office at ……. (hereinafter referred to as the 'Employer' which expression shall unless repugnant to the subject or context or meaning thereof include its successors, administrators, executors and assigns) of the one part; and …… (name of Parent/holding Company) a company organized and existing under the laws of ……. and having its Principal Office at ……. (Hereinafter referred to as the "Parent/holding Company" which expression shall unless repugnant to the subject or context or meaning thereof include its successors, administrators, executors and assigns) of the other part;

WHEREAS on the Parent/holding Company's commitment to provide full support for technical and financial requirements and be responsible and liable for successful completion of the works being awarded to M/s ……. (name of Subsidiary Company) and further agreeing to enter into a separate agreement with the Employer besides furnishing an additional Performance Bank Guarantee of value equivalent to 5% of the Accepted Contract Amount, the Employer has entered into a Contract with M/s ……. (hereinafter referred to as the "Bidder" which expression shall unless repugnant to the subject or context or meaning thereof include its successors, administrators, executors and permitted assigns) for the execution of Package - ……, …… H.P. Project**.** (hereinafter referred to as the "Contract").

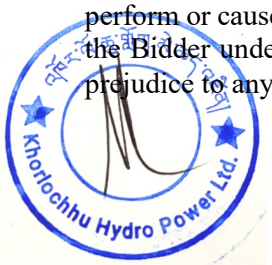
And whereas, in consideration of the aforesaid commitment, the Parent/holding Company hereby enters into this agreement with the Employer for providing full support for technical and financial requirements to the Bidder and be responsible and liable for successful performance and completion of the works described in the said Contract on the following terms and conditions:

NOW THEREFORE THE PARTIES HERETO HEREBY AGREE AND THIS AGREEMENT WITNESSETH AS FOLLOWS:

1. In this Agreement except where the context otherwise requires, the following expressions shall have the meaning hereinafter respectively assigned to them:
2. "Contract" shall mean the Contract dated …… entered into between the Employer and the Bidder for the execution of the Work described therein for Package - ……., ……. H.P. Project.

3.1 (The Parent/holding Company hereby agrees to the Employer to ensure due and faithful performance of the obligations and liabilities by the Bidder under the Contract and remain responsible to irrevocably and unconditionally provide full technical and financial support to the Bidder for completion of the works covered under the Contract. The provisions of Contract shall mutatis-mutandis apply to the Parent/holding Company.

3.2 In the event of breach and/ or failure on the part of the Bidder to perform or fulfill any of its obligations and liabilities under the Contract, the Employer may at its discretion call upon the Parent/holding Company and the Parent/holding Company shall be obliged to execute and perform or cause to be executed and performed and to satisfy the obligations and liabilities of the Bidder under the Contract in accordance with the terms and conditions thereof without prejudice to any other right or remedy, besides encashing the Bank guarantee(s).



3.3 The Parent/holding Company shall indemnify and keep indemnified and harmless the Employer at all times against any loss, damage, cost charge and expense whatsoever that may be suffered or incurred by or caused to the Employer on account of such breach.

3.4 It shall not be necessary for the Employer to proceed against the Bidder before proceeding against the Parent/holding Company and the Parent/holding Company shall be liable to fulfill its obligations and liabilities hereunder notwithstanding the Employer having undertaken any proceedings and/or obtaining any security from the Bidder for the performance of its obligations under the Contract. In order to give affect to this Agreement, the Employer may at its option be entitled to act as if the Parent/holding Company was the Bidder for successful completion of the works.

In the event, qualification of the Bidder/Subsidiary Company is considered on the credentials of another Subsidiary/Group Company under the same Apex 'Parent/holding Company' and due to any reason whatsoever, 'Parent/holding Company' or any other Group Company wants to divest its investment in the direct or indirect subsidiary (ies) as a result of which any of these companies may not remain subsidiary (ies) of the 'Parent/holding Company' then the 'Parent/holding Company' undertakes to ensure the performance of the works by arranging the required inputs in case of failure of Subsidiary Company.

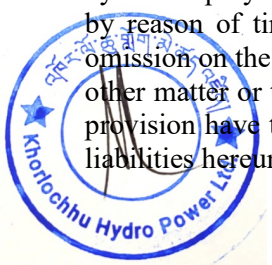
3.5 However, where the Bidder disputes the occurrence of a breach under the Contract and if such dispute is referred to arbitration in terms of Conditions of the Contract, the Bidder is obliged to carry on the works under the Contract. In case, during the pendency of the dispute in arbitration, the Bidder does not carry on the work satisfactorily, the Employer by notice to the Parent/holding Company shall be entitled to invoke this Agreement, as if a breach had occurred for the purpose of Clause 3(b) hereinabove.

4. It is agreed that the obligations undertaken by the Parent/holding Company hereunder shall be performed by it notwithstanding any difference or dispute between the Employer and the Bidder pending before any court, tribunal, arbitration or any other authority or forum.

5. This Agreement shall come into force and effect upon the Commencement Date of the Contract/issuance of 'Letter of Acceptance' and shall remain in force and effective till the date of expiry of the Defects Notification Period by the Employer pursuant to the Conditions for the Contract.

6. This guarantee is in addition to and without prejudice to the securities offered by and on behalf of Bidder to the Employer and all rights and remedies in respect thereof be reserved. This guarantee shall be a continuing guarantee and be in force notwithstanding discharge of Bidder by operation of any law or insolvency/bankruptcy /winding up/dissolution of the Bidder.

7. The Employer shall have the full liberty from time to time to vary any of the terms and conditions of the Contract by mutual agreement between the Employer and the Bidder and to extend time for performance thereunder by the Bidder or any other party thereto in accordance with the terms of the Contract and / or to postpone for any time and from time to time any of the powers exercisable by the Employer against the Bidder and either to enforce or forebear from enforcing any of the terms and conditions of the Contract and/or the securities available to the Employer from the Bidder and the Parent/holding Company shall not be released from its obligations and liabilities under this Agreement in any manner whatsoever by any exercise by the Employer of the liberty and / or the rights with reference to the matters as aforesaid or by reason of time being given to the Bidder or any other act of forbearance, waiver or omission on the part of Employer or any indulgence by the Employer to the Bidder or of any other matter or thing whatsoever which under the law relating to sureties would but for this provision have the effect of releasing the Parent/holding Company from its obligations and liabilities hereunder.



8. Nothing contained in this Agreement shall be construed or interpreted in any way as modifying or amending or relieving in any manner whatsoever the Bidder from their obligations under the Contract.
9. This Agreement shall be interpreted and be governed under the Law of Bhutan.
10. Any dispute or difference which may arise between the parties out of or in connection with this Agreement and which the Parties are unable to settle amicably shall be settled by reference to arbitration as per General/Particular Conditions of Contract. The venue of arbitration shall be Bhutan and the arbitration shall be conducted in accordance with the Alternative Dispute Resolution Act of Bhutan 2013. The courts of Bhutan shall have exclusive jurisdiction provided however that any award made in such arbitration shall be enforceable in any court of competent jurisdiction.

IN WITNESS WHEREOF THE PARTIES HERETO HAVE PUT THEIR HANDS HEREUNTO ON THE …… DAY …… MONTH AND ….. YEAR FIRST ABOVE WRITTEN AT …….

For and on behalf of the Employer Company
(through authorized representative)

Witnesses:

1. _____(Signatures)
(Name & Address)

2. _____(Signatures)
(Name & Address)

For and on behalf of the Parent/holding

(through duly authorized representative)

Witnesses:

1._____(Signatures)
(Name & Address)

2._____(Signatures)
(Name & Address)



Form - 10: Proforma of Joint Deed of Undertaking by Subcontractor and Bidder/Contractor

(Refer ITB Sub - Clause 5.3 ii)

(To be executed on non-judicial Stamp papers/Legal Stamp of Appropriate value)

THIS DEED OF UNDERTAKING executed this ……...day of……. Two Thousand and …… by M/s. ……..., a Company incorporated under the laws of ……..
and having its Registered Office at …….. (hereinafter called the "Subcontractor" which expression shall include its successors, executors and permitted assigns), and M/s.……., a Company incorporated under the laws of ……. having its Registered Office at ……. (hereinafter called the "Bidder" which expression shall include its successors, executors and permitted/ assigns) in favour of _____, a Company reregistered under the Companies Act, 1956 having its Registered Office at _____ (hereinafter called the "Employer" which expression shall include its successors, executors and permitted assigns)

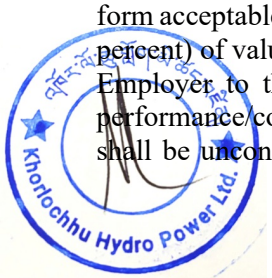
WHEREAS the "Employer" invited Bids vide its Invitation No. …… for Construction of _____.

AND WHEREAS ITB Clause No. 5.4(ii) of, Vol.–1 forming part of the Bid Documents inter-alia stipulates that a in order to ensure serious participation of the Subcontractor(s) for work proposed to be executed by the Subcontractor(s), a Joint Deed of Undertaking shall be required to be submitted by the Contractor and Subcontractor(s)

AND WHEREAS the Bidder has submitted its Bid to the Employer vide Reference No. ……..…..……. dated ……. based on the association of the Subcontractor.

NOW THEREFORE THIS UNDERTAKING WITNESSETH as under:

1. In consideration of the award of Contract by the Employer to the Bidder (hereinafter referred to as the "Contractor") we, the Subcontractor and the Bidder/Contractor do hereby declare that we shall be jointly and severally bound to the Employer, for the successful performance of the * (proposed sub-let works) in accordance with the Contract.
2. Without in any way affecting the generality and total responsibility in terms of this Deed of Undertaking, the Subcontractor in particular hereby agrees to deploy and depute its technical personnel, equipment, manpower and/or other resources on continual basis throughout the construction period of the proposed sub-let works until its completion to discharge the obligations of the Contractor under the Contract.
3. This Deed of Undertaking shall be construed and interpreted in accordance with the laws of _____ and the Courts in _____ shall have exclusive jurisdiction in all matters arising under the Undertaking.
4. Apart from the Contractor's Performance Guarantee, the Subcontractor shall furnish as security, a Contract Performance Guarantee from its Bank in favour of the Employer in a form acceptable to the Employer. The value of such guarantee shall be equivalent to 5% (five percent) of value of the proposed sub-let works as identified in the Contract awarded by the Employer to the Bidder/Contractor and it shall be an additional guarantee for faithful performance/compliance of this Deed of Undertaking in terms of the Contract. The guarantee shall be unconditional, irrevocable and valid till the completion of the part of the Works



executed by the Subcontractor. The Bank Guarantee amount shall be payable to the Employer on demand without any reservation or demur.

5. We, the Subcontractor and the Bidder/Contractor agree that this Undertaking shall be irrevocable and shall form an integral part of the Contract and further agree that this Undertaking shall continue to be enforceable till it is discharged by the Employer. It shall become operative from the Commencement Date of the Contract.

IN WITNESS WHEREOF, the Subcontractor and the Bidder/Contractor have through their Authorised Representatives executed these presents and affixed Common seals of their respective Companies, on the day, month and year first above mentioned, at ---------- (name of place).

WITNESS	For Subcontractor
1. ……	Signature of Authorized
(Signature)	(Representative
(Name in Block Letter	Name ……
(Office Address	Common Seal of Company
	……..
	For Bidder/Contractor
2. ……	Signature of Authorized
(Signature)	(Representative
(Name in Block Letter	Name ……
(Office Address	Common Seal of Company
	……..

This Joint Undertaking is to be given if the Contractor qualifies on the strength of Subcontractor.

(To be Notarized by Notary Public)



KHORLOCHHU HYDRO POWER LIMITED

4x150 MW KHORLOCHHU HYDROPOWER PROJECT

TRASHIYANGTSE; BHUTAN

BIDDING DOCUMENT

FOR

CONTRACT PACKAGE: KEM-1

DESIGN, MANUFACTURING, SUPPLY, INSTALLATION, TESTING AND COMMISSIONING OF ELECTRO-MECHANICAL WORKS

VOLUME - 3

PRICE SCHEDULES

International Competitive Bidding

These documents are meant for the exclusive purpose of bidding against this NIT and shall not be transferred, reproduced or otherwise used for purposes other than that for which they are specifically issued

Tender Ref. No. KHPL/C&PD/TENDER:KEM-1/2025/11534 dt. 07.08.2025

LAYOUT OF BIDDING DOCUMENTS

CONTRACT PACKAGE: KEM-1

Design, Manufacturing, Supply, Installation, Testing and Commissioning of Electro-Mechanical Works

Volume - 1: Instructions to Bidders (ITB)

- Section - 1 Abridged Notice Inviting Tender and Notice Inviting Tender (NIT)
- Section - 2 Instructions to Bidders (ITB), Bid Data, Qualification Forms, Information for Bidders (IFB) and Work Schedule

Volume - 2: General Conditions of Contract (GCC) and Particular Conditions of Contract (PCC)

- Section - 3 FIDIC General Conditions of Contract (GCC) for Plant and Design-Build Contract (First Edition 1999)
- Section - 5 Forms and Procedures
  - Form-1: Letter of Tender
  - Form-2: Form of Contract Agreement
  - Form-3: Bank Guarantee Form for Performance Security
  - Form-4: Bank Guarantee Form for Advance Payment
  - Form-5: Form of Taking Over Certificate
  - Form-6: Bank Guarantee Form for Release of Retention Money
  - Form-7: Hindrance Register
  - Form-8: Dispute Adjudication Agreement
  - Form-9: Parent/Holding Company Agreement
  - Form-10: Proforma for Joint Deed of Undertaking

Volume-3: Price Schedules

Volume-4: Employer's Requirements

- Section - 6 General Technical Specifications (GTS)
- Section - 7 Particular Technical Specifications (PTS)
- Section - 8 Quality Assurance Plan (QAP)

Volume-5: Tender Drawings

Volume-6: Technical Data Sheets

Khorlochhu Hydro Power Ltd.

August 2025

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Khorlochhu Hydro Power Ltd.

August 2025

Price Schedules

The Bidder shall complete the Price Schedules furnished and as indicated in the bidding documents

BID Prices

1. Unless otherwise specified in the Technical Specifications, Bidders shall quote for the entire Electro-Mechanical works under KEM-I scope on a "single responsibility" basis such that the total bid price covers all the Bidder's obligations mentioned in or to be reasonably inferred from the bidding documents in respect of the design, manufacture, including procurement and subcontracting (if any), delivery, site storage, insurance, construction, installation and completion/commissioning, including supply of Tools & Instruments, Specified spares and recommended tools & spares (if any). This includes all requirements under the Bidder's responsibilities for testing, pre-commissioning and commissioning of the Electro-Mechanical Works and, where so required by the bidding documents, the acquisition of all permits, approvals and licenses, etc., training services and such other items and services as may be specified in the bidding documents, all in accordance with the requirements of the General & Particular Conditions of Contract and Technical specifications.

2. Bidders are required to quote the price for the commercial, contractual and technical obligations outlined in the bidding documents.

3. The storage facilities shall be constructed at site as per manufacturer's instruction for equipment storage or other relevant standard. The manufacturer's guidelines or relevant standard for site storages shall be furnished to the Employer prior to the construction of the site storage facilities. The Contractors shall consider the cost of such facilities in their price bid.

4. Bidders shall give a breakdown of the prices in the manner and detail called for in the Price Schedules.

   Separate numbered Price Schedules shall be used for each of the following elements. The total amount from each Price Schedule (1 to 2) shall be summarized in Abstract of Price giving the total bid price(s) to be entered in the Bid Form.

Abstract of Price		
Price Schedule-1	:	Supply of Plant and Equipment
Price Schedule-1.1	:	Plant and Equipment Supplied from Bhutan and India
Price Schedule-1.2	:	Plant and Equipment Supplied from Country other than Bhutan and India
Price Schedule-2	:	Installation, testing, commissioning (inclusive of loading, transportation from site store to place of installation, unloading), insurance and site storage.
Price Schedule-3	:	Recommended Spare Parts and Tools & Tackles

   Bidders shall note that the plant and equipment included in Price Schedule-1 above exclude materials used for civil, building and other construction works. All materials, construction of site stores including consumables required for site storage, erection, testing, pre-commissioning and commissioning activities shall be included and priced under Price Schedule-2.

5. In the Price Schedules, Bidders shall give the required details and a breakdown of their prices as follows:

   a) Plant and equipment including specified Spares and Tools & Tackles manufactured or fabricated shall be quoted on an EXW (ex-factory, ex-works, ex-warehouse or off-the-shelf, as applicable) basis. The prices shall be inclusive of all costs, as well as duties and taxes paid or payable on all inputs utilized for manufacture/ fabrication of these supplies.

   b) Export of Goods or Services to Bhutan are considered as "zero rated supply" under "THE INTEGRATED GOODS AND SERVICES TAX ACT, 2017" (IGST) & subsequent

notifications related to IGST, and will also qualify for all the benefits available to Zero Rated Supplies under the GST regime, provided the payment for such service has been received by the supplier/contractor of service in convertible foreign exchange or in Indian rupees wherever permitted by the Reserve Bank of India.

In order to avail the benefits of input tax reimbursement as permissible in case Zero Rated Supplies under the GST regime in India, if the Contractor desires to receive payment in Indian Rupees, the same shall be made by the Employer against the request of the Contractor for those items only for which Contractor wants to avail benefits of input tax reimbursement. All other activities related to input tax reimbursement from concerned GST Department in India shall be the responsibility of Contractor. The Contractor shall solely be responsible for obtaining above benefits, which they have considered in their bid and in case of failure to receive such benefits; the Employer will not compensate the Bidder.

c) Price Schedule-1 shall be inclusive of transportation, transit insurance, port clearance and port charges and other costs incidental to delivery of the Plant and equipment including specified spares and Tools & Instruments. Rates quoted in this Price Schedule shall be inclusive of all taxes, duties, levies and charges payable including GST etc., if applicable, in India/Bhutan as of twenty eight (28) days prior to deadline for submission of Price bids. The Employer, as an importer, shall furnish promptly necessary certifications and documents as may be required to be furnished by the importer for the purpose of customs clearance.

d) Installation Services shall be quoted separately (Price Schedule-2) and shall include rates or prices for all labour, contractor's equipment, temporary works, materials, consumables and all matters and things of whatsoever nature, the provision of operations and maintenance manuals, training, etc., where identified in the bidding documents, as necessary for the proper execution of the Installation Services, including all taxes, duties, levies and charges payable including GST etc., if applicable, in India/Bhutan as of twenty-eight (28) days prior to the deadline for submission of bids.

6. The terms EXW etc., shall be governed by the rules prescribed in the current edition of INCOTERMS, published by the International Chamber of Commerce, 38 Cours Albert 1er, 75008 Paris, France.

7. Price Shall be quoted in Ngultrum/Indian Rupee (BTN/INR) or Euro (EUR). However, part payment in Indian Rupees may be allowed as per Sub-Clause 5(b) above.

8. The price of Recommended Spares Parts, Recommended Special Tools and Transportation (Including Port Clearance & Port Charges, if applicable) & Transit Insurance for Recommended Spares Parts & Recommended Special Tools quoted in Price Schedules No.3 shall not be considered for evaluation.

9. The package shall be evaluated as a whole and the evaluation of the bids shall be done on total quoted prices for the total Package as per Price Schedules. In case the Bidder has not quoted for any of the items, the price of all such item(s) against which Bidder has not quoted rates/ amount (viz. items left blank or Zero) in the Price Schedules will be deemed to have been included in other item(s)/ Total Quoted amount.

10. The Price Schedule do not generally give a full description of the plant to be supplied and the services to be performed under each item. Bidders shall be deemed to have read the Employer's Requirements and other sections of the Bidding Document and reviewed the Drawings to ascertain the full scope of the requirements included in each item prior to filling in the rates and prices. The entered rates and prices shall be deemed to cover the full scope as aforesaid, including overheads and profit.

11. If Bidders are unclear or uncertain as to the scope of any item, they shall seek clarification in accordance with ITB 10 prior to submitting their bid.

12. Price shall be filled in indelible ink, and any alterations necessary due to errors, etc., shall be

initialled by the Bidder.

13. When requested by the Employer for the purposes of making payment or part payments, valuing variations or evaluating claims, or for such other purposes as the employer may reasonably require, the Contractor shall provide the Employer with a breakdown of any composite or lump sum items included in the Price Schedule.



ABSTRACT OF PRICE

PS No.	Description	Total Price in figures (BTN/INR)	Total Price in figures (EUR)
Price Schedule-1: Supply of Plant and Equipment			
1.1	Plant and Equipment Supplied from Bhutan and India		
1.2	Plant and Equipment Supplied from Country other than Bhutan and India		
Price Schedule 2: Services			
2.1	Installation, Testing, Commissioning Works		
	Grand Total		

Total Amount in words……)

Seal/Signature of Bidder…..……

PRICE SCHEDULE-1

1.1 PLANT AND EQUIPMENT SUPPLIED FROM BHUTAN AND INDIA

Item No.	Description of Items	Make/ Country of Origin	Qty.	Unit Price (BTN/INR)				Total Cost up to Project Site (BTN/INR)
				Ex-works Price inclusive of packing and forwarding		Transportation Charges up to Project Site including CIP		
				(In figures)	(In Words)	(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)		(6)		(7= 4x (5+6))
1.0	**Turbine and Accessories**							
1.1	375 rpm Vertical axis Pelton Turbines with rated output of 152.3 MW + 10% continuous overload capacity at design head of 761.53 m with nozzle opening not more than 85% complete in all respects as per Chapter-1 defined in Section-7 of Volume-4.		4 Sets					
1.2	Complete set of Tools and Instruments as per clause 1.15 of Chapter-1 under Section-7 of Volume-4 (Employer's requirement and Additional list to be given as per clause of 2.1.5 of Data Sheet-1: Technical Particular under Volume-6).		1 Lot					
1.3	Mandatory Spare parts as per clause 1.13 of Chapter-1 under Section-7 of Volume-4		1 Lot					
1.4	Turbine Modelling and Testing in approved laboratory.		1 Lot					
	Sub-Total 1 (1.1 to 1.4)							
2.0	**Digital Governing System and Accessories**							
2.1	Digital Electronic Hydraulic Governors comprising regulator consoles & hydraulic		4 Sets					

Item No.	Description of Items	Make/ Country of Origin	Qty.	Unit Price (BTN/INR)				Total Cost up to Project Site (BTN/INR)
				Ex-works Price inclusive of packing and forwarding		Transportation Charges up to Project Site including CIP		
				(In figures)	(In Words)	(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)		(6)		(7= 4x (5+6))
	actuator units complete in all respects for Vertical Axis Pelton Turbine as per Chapter-2 defined in Section-7 of Volume-4.							
2.2	Mandatory Spare parts as per clause 2.11 of Chapter-2 under Section-7 of Volume-4		1 Lot					
2.3	Complete set of Tools and Instruments as per clause 2.13 of Chapter-2 under Section-7 of Volume-4.		1 Lot					
	Sub-Total 2 (2.1 to 2.3)							
3.0	**Main Inlet Valves and Accessories**							
3.1	1.7 m diameter Main Inlet Valves of spherical type assembly including oil pumping units, pressure and sump tanks, allied valves, piping etc. complete in all respects as per Chapter-6 defined in Section-7 of Volume-4.		4 Sets					
3.2	Mandatory Spare parts as per clause 3.11 of Chapter-6 under Section-7 of Volume-4		1 Lot					
3.3	Complete set of Tools and Instruments as per clause 6.13 of Chapter-6 under Section-7 of Volume-4.		1 Lot					
	Sub-Total of 3 (3.1 to 3.3)							
4.0	**Butterfly Valve and Accessories**							

Item No.	Description of Items	Make/ Country of Origin	Qty.	Unit Price (BTN/INR)				Total Cost up to Project Site (BTN/INR)
				Ex-works Price inclusive of packing and forwarding		Transportation Charges up to Project Site including CIP		
				(In figures)	(In Words)	(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)		(6)		(7= 4x (5+6))
4.1	3.3 m diameter Butterfly Valve assembly complete in all respect comprising of valve bodies, rotor/ plug, trunnions and counter weights, together with bearings, service seal, maintenance seal etc. complete in all respects as per Chapter-4 defined in Section-7 of Volume-4		2 Sets					
4.2	Mandatory Spare parts as per clause 4.11 of Chapter-4 under Section-7 of Volume-4		1 Lot					
4.3	Complete set of Tools and Instruments as per clause 4.13 of Chapter-4 under Section-7 of Volume-4.		1 Lot					
	Sub-Total of 4 (4.1 to 4.3)							
5.0	**Generator and Accessories**							
5.1	Vertical Shaft Generators of rated output of 150 MW + 10% continuous overload capacity with closed air circulating type cooling system complete with stator, rotor, shaft, thrust and guide bearings complete in all respects as per Chapter-5 defined in Section-7 of Volume-4.		4 sets					
5.2	Mandatory Spare parts as per clause 5.30 of Chapter-5 under Section-7 of Volume-4		1 Lot					
5.3	Complete set of Tools and Instruments as per clause 5.24 of Chapter-5 under Section-7 of Volume-4.		1 Lot					

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Item No.	Description of Items	Make/ Country of Origin	Qty.	Unit Price (BTN/INR)				Total Cost up to Project Site (BTN/INR)
				Ex-works Price inclusive of packing and forwarding		Transportation Charges up to Project Site including CIP		
				(In figures)	(In Words)	(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)		(6)		(7= 4x (5+6))
	Sub-Total of 5(5.1 to 5.3)							
6.0	**Excitation System**							
6.1	Excitation System complete in all respects as per Chapter-6 defined in Section-7 of Volume-4.		4 sets					
6.2	Mandatory Spare parts as per clause 6.28.1 of Chapter-6 under Section-7 of Volume-4		1 Lot					
6.3	Complete set of Tools and Instruments as per clause 6.30 of Chapter-6 under Section-7 of Volume-4.		1 Lot					
	Sub-Total of 6(6.1 to 6.3)							
7.0	**Isolated Phase Bus Ducts and Accessories**							
7.1	Isolated Phase Busduct (IPBD) & accessories along with neutral grounding transformer & resistor, LAVT cubicles, dynamic braking switch, for each unit per Chapter-7 defined in Section-7 of Volume-4.		4 Sets					
7.2	Mandatory Spare parts as per clause 7.5 of Chapter-7 under Section-7 of Volume-4		1 Lot					
	Sub-Total of 7 (7.1 to 7.2)							
8.0	**Generator Transformer**							

Khorlochhu Hydro Power Ltd.

Item No.	Description of Items	Make/ Country of Origin	Qty.	Unit Price (BTN/INR)				Total Cost up to Project Site (BTN/INR)
				Ex-works Price inclusive of packing and forwarding		Transportation Charges up to Project Site including CIP		
				(In figures)	(In Words)	(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)		(6)		(7= 4x (5+6))
8.1	Generator Transformers (1Ph) complete in all respects as per Chapter-8 defined in Section-7 of Volume-4.		12 sets + 1 spare					
8.2	Interconnecting Transformer (1Ph) with Nitrogen Injection Fire protection system (NIFPS) for power evacuation/drawl along with all necessary equipment & accessories, etc. all respects as per Chapter-8 defined in Section-7 of Volume-4.		3 Sets + 1 spare					
8.3	3-phase, 80 MVAr Shunt reactor for 400 kV system with all necessary equipment & accessories, etc. as per Chapter 8 under Section-7 of Volume-4.		1 Set					
8.4	Mandatory Spare parts as per clause 8.38 and 8.51 of Chapter-8 under Section-7 of Volume-4		1 Lot					
8.5	Complete set of Tools and Instruments as per clause 8. 44 of Chapter-4 under Section-7 of Volume-4.		1 Lot					
	Sub-Total of 8 (8.1 to 8.5)							
9.0	**Gas Insulated Switchyard (GIS)**							
9.1	400 kV GIS substation for power evacuation/drawl along with all necessary equipment & accessories, etc. (GT bay-4 Nos, ICT Bay- 1 No, Reactor Bay-1 No, Line Bay-2 Nos, Bus coupler-1 No, Bus PT-2 Nos, Double		1 Lot					

Item No.	Description of Items	Make/ Country of Origin	Qty.	Unit Price (BTN/INR)				Total Cost up to Project Site (BTN/INR)
				Ex-works Price inclusive of packing and forwarding		Transportation Charges up to Project Site including CIP		
				(In figures)	(In Words)	(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)		(6)		(7= 4x (5+6))
	bus arrangement) as per Chapter 9 under Section-7 of Volume-4.							
9.2	Mandatory Spare parts as per clause 9.40 of Chapter-9 under Section-7 of Volume-4		1 Lot					
9.3	Complete set of Tools and Instruments as per clause 9.34 of Chapter-9 under Section-7 of Volume-4.		1 Lot					
	Sub-Total of 9 (9.1 to 9.3)							
10.0	**420 kV and 145 kV XLPE Cables**							
10.1	420kV and 145 kV XLPE cables as per Chapter 10 defined in Section -7 of Volume-4		1 Lot					
10.2	Mandatory Spare parts as per clause 10.20 of Chapter-10 under Section-7 of Volume-4		1 Lot					
10.3	Complete set of Tools and Instruments as per clause 10.17 of Chapter- 10 under Section-7 of Volume-4.		1 Lot					
	Sub-Total of 10 (10.1 to 10.3)							
11.0	**Pothead Yard**							
11.1	400 kV Pothead yard along with all necessary equipment & accessories, etc. in all respect as per Chapter-11 defined in Section-7 of Volume-4.		1 Lot					

Item No.	Description of Items	Make/ Country of Origin	Qty.	Unit Price (BTN/INR)				Total Cost up to Project Site (BTN/INR)
				Ex-works Price inclusive of packing and forwarding		Transportation Charges up to Project Site including CIP		
				(In figures)	(In Words)	(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)		(6)		(7= 4x (5+6))
11.2	Mandatory Spare parts as per clause 11.20 of Chapter-11 under Section-7 of Volume-4		1 Lot					
11.3	Complete set of Tools and Instruments as per clause 11.16 of Chapter-11 under Section-7 of Volume-4.		1 Lot					
	Sub-Total of 11 (11.1 to 11.3)							
12.0	**Cooling Water System**							
12.1	Cooling Water System and accessories complete in all respects as per Chapter-12 defined in Section-7 of Volume-4.		4 Sets					
12.2	Mandatory Spare parts as per clause 12.12 of Chapter-12 under Section-7 of Volume-4		1 Lot					
12.3	Complete set of Tools and Instruments as per clause 12.14 of Chapter-12 under Section-7 of Volume-4.		1 Lot					
	Sub-Total of 12 (12.1 to 12.3)							
13.0	**LP Compressed Air System**							
13.1	Compressed air system complete in all respects as per chapter-13 defined in section-7 of volume-4.		2 set					
13.2	Mandatory Spare parts as per clause 13.12 of Chapter-13 under Section-7 of Volume-4		1 set					

Item No.	Description of Items	Make/ Country of Origin	Qty.	Unit Price (BTN/INR)				Total Cost up to Project Site (BTN/INR)
				Ex-works Price inclusive of packing and forwarding		Transportation Charges up to Project Site including CIP		
				(In figures)	(In Words)	(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)		(6)		(7= 4x (5+6))
13.3	Complete set of tools and instruments as per clause 13.14 of chapter-13 under section-7 of volume-4.		1 Lot					
	Sub-Total of 13 (13.1 to 13.3)							
14.0	**Drainage and Dewatering System**							
14.1	Drainage and Dewatering System complete in all respects as per Chapter-14 defined in Section-7 of Volume-4.		1 set					
14.2	Mandatory Spare parts as per clause 14.12 of Chapter-14 under Section-7 of Volume-4		1 Set					
14.3	Complete set of tools and instruments as per clause 14.14 of chapter-13 under section-7 of volume-4.		1 Lot					
	Sub-Total of 14 (14.1 to 14.3)							
15.0	**220V DC System**							
15.1	220V system complete with battery, battery health monitoring system, chargers and distribution boards (1 Set for Powerhouse and 1 Set for BFV Area.) as per Chapter-15 defined in Section-7 of Volume-4.		1 Lot					
15.2	Mandatory Spare parts as per clause 15.12 of Chapter-15 under Section-7 of Volume-4		1 Lot					

Item No.	Description of Items	Make/ Country of Origin	Qty.	Unit Price (BTN/INR)				Total Cost up to Project Site (BTN/INR)
				Ex-works Price inclusive of packing and forwarding		Transportation Charges up to Project Site including CIP		
				(In figures)	(In Words)	(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)		(6)		(7= 4x (5+6))
15.3	Complete set of Tools and Instruments as per clause 15.16 of Chapter-15 under Section-7 of Volume-4.		1 Lot					
	Sub-Total of 15 (15.1 to 15.3)							
16.0	**Uninterrupted Power Supply (UPS)**							
16.1	230 V AC UPS with batteries (2 sets at Powerhouse control room, 1 set at SCADA System, 1 set at DAM Gate control building, 1 set at Chaplangchhu Intake control building)		1 Lot					
16.2	Mandatory Spare parts as per clause 16.15 of Chapter-16 under Section-7 of Volume-4		1 Lot					
	Sub-Total of 16 (16.1 to 16.2)							
17.0	**Heating, Ventilation and Air Conditioning (HVAC) System**							
17.1	HVAC system complete in all respects as per Chapter-17 defined in section-7 of volume-4.		1 set					
17.2	Mandatory Spare parts as per clause 17.14 of Chapter-17 under Section-7 of Volume-4		1 Lot					
17.3	Complete set of Tools and Instruments as per clause 17.16 of Chapter-17 under Section-7 of Volume-4		1 Lot					
	Sub-Total of 17 (17.1 to 17.3)							
18.0	**Cable and Cabling System**							

Item No.	Description of Items	Make/ Country of Origin	Qty.	Unit Price (BTN/INR)				Total Cost up to Project Site (BTN/INR)
				Ex-works Price inclusive of packing and forwarding		Transportation Charges up to Project Site including CIP		
				(In figures)	(In Words)	(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)		(6)		(7= 4x (5+6))
18.1	Cable and cabling system complete in all respects as per Chapter-18 defined in section-7 of volume-4.		1 set					
18.2	Mandatory Spare parts as per clause 18.26 of Chapter-18 under Section-7 of Volume-4		1 Lot					
	Sub-Total of 18 (18.1 to 18.2)							
19.0	**Electric Overhead Travelling (EOT) Cranes**							
19.1	200T/40T/10T Electric Overhead Travelling Cranes for Machine Hall complete in all respects as per Chapter-19 defined in Section-7 of Volume-4.		2 Sets					
19.2	Equalizer beam, fittings, connections, electric controls and other accessories required when 200/ 40/10 tonnes EOT cranes are operating in tandem for lifting rotor		1 No.					
19.3	60T/15T Electric Overhead Travelling Crane for Butterfly Valve Cavern complete in all respects as per Chapter-19 defined in Section-7 of Volume-4.		1 Set					
19.4	10T Electric Overhead Travelling Crane for GIS Hall complete in all respects as per Chapter-7 defined in Section-19 of Volume-4.		1 Set					
19.5	Mandatory Spare parts as per clause 19.12 of Chapter-19 under Section-7 of Volume-4		1 Lot					

Khorlochhu Hydro Power Ltd.

Item No.	Description of Items	Make/ Country of Origin	Qty.	Unit Price (BTN/INR)				Total Cost up to Project Site (BTN/INR)
				Ex-works Price inclusive of packing and forwarding		Transportation Charges up to Project Site including CIP		
				(In figures)	(In Words)	(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)		(6)		(7= 4x (5+6))
19.6	Complete set of Tools and Instruments as per clause 19.14 of Chapter-19 under Section-7 of Volume-4.		1 Lot					
	Sub-Total of 19 (19.1 to 19.6)							
20.0	**Fire Protection System**							
20.1	Fire Protection system complete in all respects as per Chapter-20 defined in Section-7 of Volume-4.		1 Lot					
20.2	Mandatory Spare parts as per Clause 20.24 of Chapter-20 under Section-7 of Volume-4		1 Lot					
20.3	Complete set of Tools and Instruments as per Clause 20.23 of Chapter-20 under Section-7 of Volume-4.		1 Lot					
	Sub-Total of 20 (20.1 to 20.3)							
21.0	**Fire Detection and Alarm System**							
21.1	Fire Detection & Alarm system (FDA) for entire for entire Hydro plant including GIS & pothead yard shall be as per NFPA guidelines & local statutory regulations in all respect as per Chapter 21 defined in Section-7 of Volume-4.		1 Set					
21.2	Mandatory Spare parts as per Clause 21.27 of Chapter 21 under Section-7 of Volume-4		1 Lot					

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Item No.	Description of Items	Make/ Country of Origin	Qty.	Unit Price (BTN/INR)				Total Cost up to Project Site (BTN/INR)
				Ex-works Price inclusive of packing and forwarding		Transportation Charges up to Project Site including CIP		
				(In figures)	(In Words)	(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)		(6)		(7= 4x (5+6))
21.3	Complete set of Tools and Instruments as per Clause 21.18 of Chapter 21 under Section-7 of Volume-4.		1 Lot					
	Sub-Total of 21 (21.1 to 21.3)							
22.0	**MV Switchgear**							
22.1	MV Indoor Switchgears, Unit/Station/Service transformers, Segregated / Non-Segregated phase busduct (SPBD/NAPBD), 33/11 kV switchgear and distribution boards for complete plant as per Chapter-22 defined in section-7 of volume-4.		1 set					
22.2	Mandatory Spare parts as per clause 22.22 of Chapter-22 under Section-7 of Volume-4		1 Lot					
	Sub-Total of 21 (21.1 to 21.2)							
23.0	**LV Switchgear**							
23.1	415V switchgear and distribution boards for complete plant as per Chapter-23 defined in section-7 of volume-4.		1 Lot					
23.2	Mandatory Spare parts as per clause 23.27 of Chapter-23 under Section-7 of Volume-4		1 Lot					
23.3	Complete set of Tools and Instruments as per clause 23.23 of Chapter-23 under Section-7 of Volume-4.		1 Lot					

Item No.	Description of Items	Make/ Country of Origin	Qty.	Unit Price (BTN/INR)				Total Cost up to Project Site (BTN/INR)
				Ex-works Price inclusive of packing and forwarding		Transportation Charges up to Project Site including CIP		
				(In figures)	(In Words)	(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)		(6)		(7= 4x (5+6))
	Sub-Total of 23 (23.1 to 23.3)							
24.0	**Auxilary Transformer**							
24.1	Service Transformers along with all necessary equipment & accessories, etc. for plant inhouse power distributions. 2 Nos. Station Auxiliary Transformer 33/11kV Unit Auxiliary Transformer. (4 MVA, 13.9/0.433kV- 4 Nos.) Station Auxiliary Transformer. (2.5 MVA, 11/0.433kV- 4 Nos.) Pothead yard Auxiliary Transformer (200 kVA, 11/0.433kV- 1 No.) 33kV Service Transformer, (500 KVA, 3-Ph 33 kV / 0.433kV, 4 No.) 33kV Service Transformer 200 KVA, 3-Ph, 33 kV / 0.433kV, 2 No.) Excitation transformer. (1 MVA, 13.9/0.433kV- 4 No.) as per Chapter-24 defined in Section-7 of Volume-4.		1 Lot					
24.2	Mandatory Spare parts as per clause 24.22 of Chapter-24 under Section-7 of Volume-4		1 Lot					
	Sub-Total of 24 (24.1 to 24.2)							
25.0	**Lighting System**							

Item No.	Description of Items	Make/ Country of Origin	Qty.	Unit Price (BTN/INR)				Total Cost up to Project Site (BTN/INR)
				Ex-works Price inclusive of packing and forwarding		Transportation Charges up to Project Site including CIP		
				(In figures)	(In Words)	(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)		(6)		(7= 4x (5+6))
25.1	Plant Indoor and Outdoor lighting system for entire Hydro plant including GIS & pothead yard as per Chapter-25 defined in Section-7 of Volume-4.		1 Lot					
25.2	Mandatory Spare parts as per clause 25.24 of Chapter-25 under Section-7 of Volume-4		1 Lot					
	Sub-Total of 25 (25.1 to 25.2)							
26.0	**Grounding And Lightning Protection System**							
26.1	Grounding and Lightening Protection System complete in all respects as per Chapter-26 defined in Section-7 of Volume-4.		1 Lot					
26.2	Mandatory Spares as per clause 26.12 of Chapter-26 under Section-7 of Volume-4.		1 Lot					
	Sub-Total of 26 (26.1 to 26.2)							
27.0	**Diesel Generator Set**							
27.1	Diesel Generator Set complete in all respects as per Chapter-27 defined in section-7 of volume-4.		1 Lot					
27.2	Complete set of Tools and Instruments as per clause 27.13 of Chapter-27 under Section-7 of Volume-4		1 Lot					
	Sub-Total of 27 (27.1 to 27.2)							

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Item No.	Description of Items	Make/ Country of Origin	Qty.	Unit Price (BTN/INR)				Total Cost up to Project Site (BTN/INR)
				Ex-works Price inclusive of packing and forwarding		Transportation Charges up to Project Site including CIP		
				(In figures)	(In Words)	(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)		(6)		(7= 4x (5+6))
28.0	**Oil Handling and Purification System**							
28.1	Lubrication Oil Handling and Purification System complete in all respects as per Chapter-28 defined in Section-7 of Volume-4.		1 Set					
28.2	Mandatory Spare parts as per clause 28.13 of Chapter-28 under Section-7 of Volume-4		1 Lot					
28.3	Complete set of Tools and Instruments as per clause 28.15 of Chapter-28 under Section-7 of Volume-4.		1 Lot					
	Sub-Total of 28 (28.1 to 28.3)							
29.0	**Electrical and Mechanical Workshop Equipment**							
29.1	Electrical and mechanical workshop equipment complete in all respects as per Chapter-29 defined in Section-7 of Volume-4		1 Lot					
29.2	Mandatory Spares as per Annexure-I.		1 Lot					
	Sub-Total of 29(29.1 to 29.2)							
30.0	**Plant Communication & Public Addressing System**							
30.1	Plant communication & Public Addressing System & accessories, etc in all respect as per Chapter-30 defined in Section-7 of Volume-4.		1 Lot					
30.2	Mandatory Spare parts as per clause 30.20 of Chapter-30 under Section-7 of Volume-4		1 Lot					

Item No.	Description of Items	Make/ Country of Origin	Qty.	Unit Price (BTN/INR)				Total Cost up to Project Site (BTN/INR)
				Ex-works Price inclusive of packing and forwarding		Transportation Charges up to Project Site including CIP		
				(In figures)	(In Words)	(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)		(6)		(7= 4x (5+6))
	Sub-Total of 30 (30.1 to 30.2)							
31.0	**Security and Surveillance System**							
31.1	Plant communication & Public Addressing System & accessories, etc in all respect as per Chapter-31 defined in Section-7 of Volume-4.		1 Lot					
31.2	Mandatory Spare parts as per clause 31.8 of Chapter-31 under Section-7 of Volume-4		1 Lot					
31.3	Complete set of Tools and Instruments as per clause 31.9 of Chapter-31 under Section-7 of Volume-4.		1 Lot					
	Sub-Total of 31 (31.1 to 31.3)							
32.0	**Fibre Optic Communication System**							
32 .1	Fibre Optic communication system along with all necessary equipment & accessories, etc in all respect as per Chapter-32 defined in Section-7 of Volume-4.		1 Lot					
32 .2	Mandatory Spare parts as per clause 32 .58 and detailed in 32.69 of Chapter-32 under Section-7 of Volume-4		1 Lot					
32 .3	Complete set of Tools and Instruments as per clause 32 .59 of Chapter-32 under Section-7 of Volume-4.		1 Lot					

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Item No.	Description of Items	Make/ Country of Origin	Qty.	Unit Price (BTN/INR)				Total Cost up to Project Site (BTN/INR)
				Ex-works Price inclusive of packing and forwarding		Transportation Charges up to Project Site including CIP		
				(In figures)	(In Words)	(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)		(6)		(7= 4x (5+6))
	Sub-Total of 32 (32.1 to 32.3)							
33.0	**132 kV Switchyard (ICT Bay)**							
33.1	132 kV Switch yard Bay along with all necessary equipment & accessories, etc. at Korlung Substation in all respect as per Chapter-33 defined in Section-7 of Volume-4.		1 Lot					
	Sub-Total of 33 (33.1)							
	TOTAL (1 to 33) of Price Schedule-1.1							

Note: *List for Mandatory Spares are attached as Annexure-I.*

Khorlochhu Hydro Power Ltd.

1.2 PLANT AND EQUIPMENT SUPPLIED FROM COUNTRY OTHER THAN BHUTAN AND INDIA

Item No.	Description of Items	Make/ Country of Origin	Qty.	Unit Price (EUR)				Total Cost up to Project Site (EUR)
				Ex-works Price inclusive of packing and forwarding		Transportation Charges up to Project Site including CIP		
				(In figures)	(In Words)	(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)		(6)		(7= 4x (5+6))
1.0	**Turbine and Accessories**							
1.1	375 rpm Vertical axis Pelton Turbines with rated output of 152.3 MW + 10% continuous overload capacity at design head of 761.53 m with nozzle opening not more than 85% complete in all respects as per Chapter-1 defined in Section-7 of Volume-4.		4 Sets					
1.2	Complete set of Tools and Instruments as per clause 1.15 of Chapter-1 under Section-7 of Volume-4 (Employer's requirement and Additional list to be given as per clause of 2.1.5 of Data Sheet-1: Technical Particular under Volume-6).		1 Lot					
1.3	Mandatory Spare parts as per clause 1.13 of Chapter-1 under Section-7 of Volume-4		1 Lot					
1.4	Turbine Modelling and Testing in approved laboratory.		1 Lot					
	Sub-Total 1 (1.1 to 1.4)							
2.0	**Digital Governing System and Accessories**							
2.1	Digital Electronic Hydraulic Governors comprising regulator consoles & hydraulic actuator units complete in all respects for Vertical Axis Pelton Turbine as per Chapter-2 defined in Section-7 of Volume-4.		4 Sets					

Item No.	Description of Items	Make/ Country of Origin	Qty.	Unit Price (EUR)				Total Cost up to Project Site (EUR)
				Ex-works Price inclusive of packing and forwarding		Transportation Charges up to Project Site including CIP		
				(In figures)	(In Words)	(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)		(6)		(7= 4x (5+6))
2.2	Mandatory Spare parts as per clause 2.11 of Chapter-2 under Section-7 of Volume-4		1 Lot					
2.3	Complete set of Tools and Instruments as per clause 2.13 of Chapter-2 under Section-7 of Volume-4.		1 Lot					
	Sub-Total 2 (2.1 to 2.3)							
3.0	**Main Inlet Valves and Accessories**							
3.1	1.7 m diameter Main Inlet Valves of spherical type assembly including oil pumping units, pressure and sump tanks, allied valves, piping etc. complete in all respects as per Chapter-6 defined in Section-7 of Volume-4.		4 Sets					
3.2	Mandatory Spare parts as per clause 3.11 of Chapter-6 under Section-7 of Volume-4		1 Lot					
3.3	Complete set of Tools and Instruments as per clause 6.13 of Chapter-6 under Section-7 of Volume-4.		1 Lot					
	Sub-Total of 3 (3.1 to 3.3)							
4.0	**Butterfly Valve and Accessories**							
4.1	3.3 m diameter Butterfly Valve assembly complete in all respect comprising of valve bodies, rotor/ plug, trunnions and counter weights, together with bearings, service seal, maintenance seal etc. complete in all respects as per Chapter-4 defined in Section-7 of Volume-4		2 Sets					

Item No.	Description of Items	Make/ Country of Origin	Qty.	Unit Price (EUR)				Total Cost up to Project Site (EUR)
				Ex-works Price inclusive of packing and forwarding		Transportation Charges up to Project Site including CIP		
				(In figures)	(In Words)	(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)		(6)		(7= 4x (5+6))
4.2	Mandatory Spare parts as per clause 4.11 of Chapter-4 under Section-7 of Volume-4		1 Lot					
4.3	Complete set of Tools and Instruments as per clause 4.13 of Chapter-4 under Section-7 of Volume-4.		1 Lot					
	Sub-Total of 4 (4.1 to 4.3)							
5.0	**Generator and Accessories**							
5.1	Vertical Shaft Generators of rated output of 150 MW + 10% continuous overload capacity with closed air circulating type cooling system complete with stator, rotor, shaft, thrust and guide bearings complete in all respects as per Chapter-5 defined in Section-7 of Volume-4.		4 sets					
5.2	Mandatory Spare parts as per clause 5.30 of Chapter-5 under Section-7 of Volume-4		1 Lot					
5.3	Complete set of Tools and Instruments as per clause 5.24 of Chapter-5 under Section-7 of Volume-4.		1 Lot					
	Sub-Total of 5(5.1 to 5.3)							
6.0	**Excitation System**							
6.1	Excitation System complete in all respects as per Chapter-6 defined in Section-7 of Volume-4.		4 sets					
6.2	Mandatory Spare parts as per clause 6.28.1 of Chapter-6 under Section-7 of Volume-4		1 Lot					

Item No.	Description of Items	Make/ Country of Origin	Qty.	Unit Price (EUR)				Total Cost up to Project Site (EUR)
				Ex-works Price inclusive of packing and forwarding		Transportation Charges up to Project Site including CIP		
				(In figures)	(In Words)	(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)		(6)		(7= 4x (5+6))
6.3	Complete set of Tools and Instruments as per clause 6.30 of Chapter-6 under Section-7 of Volume-4.		1 Lot					
	Sub-Total of 6(6.1 to 6.3)							
7.0	**Isolated Phase Bus Ducts (IPBD) and Accessories**							
7.1	Isolated Phase Busduct (IPBD) & accessories along with neutral grounding transformer & resistor, LAVT cubicles, dynamic braking switch, for each unit per Chapter-7 defined in Section-7 of Volume-4.		4 Sets					
7.2	Mandatory Spare parts as per clause 7.5 of Chapter-7 under Section-7 of Volume-4		1 Lot					
	Sub-Total of 7 (7.1 to 7.2)							
8.0	**Generator Transformer**							
8.1	Generator Transformers complete in all respects as per Chapter-8 defined in Section-7 of Volume-4.		12 sets + 1 spare					
8.2	Interconnecting Transformer (1Ph) with Nitrogen Injection Fire protection system (NIFPS) for power evacuation/drawl along with all necessary equipment & accessories, etc. all respects as per Chapter-8 defined in Section-7 of Volume-4.		3 Sets + 1 spare					
8.3	3-phase, 80 MVAr Shunt reactor for 400 kV system with all necessary equipment & accessories, etc. as per Chapter 8 under Section-7 of Volume-4.		1 Set					

Item No.	Description of Items	Make/ Country of Origin	Qty.	Unit Price (EUR)				Total Cost up to Project Site (EUR)
				Ex-works Price inclusive of packing and forwarding		Transportation Charges up to Project Site including CIP		
				(In figures)	(In Words)	(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)		(6)		(7= 4x (5+6))
8.4	Mandatory Spare parts as per clause 8.38 and 8.51 of Chapter-8 under Section-7 of Volume-4		1 Lot					
8.5	Complete set of Tools and Instruments as per clause 8. 44 of Chapter-4 under Section-7 of Volume-4.		1 Lot					
	Sub-Total of 8 (8.1 to 8.5)							
9.0	**Gas Insulated Switchyard (GIS)**							
9.1	400 kV GIS substation for power evacuation/drawl along with all necessary equipment & accessories, etc. (GT bay-4 Nos, ICT Bay- 1 No, Reactor Bay-1 No, Line Bay-2 Nos, Bus coupler-1 No, Bus PT-2 Nos, Double bus arrangement) as per Chapter 9 under Section-7 of Volume-4.		1 Lot					
9.2	Mandatory Spare parts as per clause 9.40 of Chapter-9 under Section-7 of Volume-4		1 Lot					
9.3	Complete set of Tools and Instruments as per clause 9.34 of Chapter-9 under Section-7 of Volume-4.		1 Lot					
	Sub-Total of 9 (9.1 to 9.3)							
10.0	**420 kV and 145 kV XLPE Cables**							
10.1	420kV and 145 kV XLPE cables as per Chapter 10 defined in Section-7 of Volume-4		1 Lot					
10.2	Mandatory Spare parts as per clause 10.20 of Chapter-10 under Section-7 of Volume-4		1 Lot					

Item No.	Description of Items	Make/ Country of Origin	Qty.	Unit Price (EUR)				Total Cost up to Project Site (EUR)
				Ex-works Price inclusive of packing and forwarding		Transportation Charges up to Project Site including CIP		
				(In figures)	(In Words)	(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)		(6)		(7= 4x (5+6))
10.3	Complete set of Tools and Instruments as per clause 10.17 of Chapter- 10 under Section-7 of Volume-4.		1 Lot					
	Sub-Total of 10 (10.1 to 10.3)							
11.0	**Pothead Yard**							
11.1	400 kV Pothead yard along with all necessary equipment & accessories, etc. in all respect as per Chapter-11 defined in Section-7 of Volume-4.		1 Lot					
11.2	Mandatory Spare parts as per clause 11.20 of Chapter-11 under Section-7 of Volume-4		1 Lot					
11.3	Complete set of Tools and Instruments as per clause 11.16 of Chapter-11 under Section-7 of Volume-4.		1 Lot					
	Sub-Total of 11 (11.1 to 11.3)							
12.0	**Cooling Water System**							
12.1	Cooling Water System and accessories complete in all respects as per Chapter-12 defined in Section-7 of Volume-4.		4 Sets					
12.2	Mandatory Spare parts as per clause 12.12 of Chapter-12 under Section-7 of Volume-4		1 Lot					
12.3	Complete set of Tools and Instruments as per clause 12.14 of Chapter-12 under Section-7 of Volume-4.		1 Lot					
	Sub-Total of 12 (12.1 to 12.3)							

Item No.	Description of Items	Make/ Country of Origin	Qty.	Unit Price (EUR)				Total Cost up to Project Site (EUR)
				Ex-works Price inclusive of packing and forwarding		Transportation Charges up to Project Site including CIP		
				(In figures)	(In Words)	(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)		(6)		(7= 4x (5+6))
13.0	**LP Compressed Air System**							
13.1	Compressed air system complete in all respects as per chapter-13 defined in section-7 of volume-4.		2 set					
13.2	Mandatory Spare parts as per clause 13.12 of Chapter-13 under Section-7 of Volume-4		1 set					
13.3	Complete set of tools and instruments as per clause 13.14 of chapter-13 under section-7 of volume-4.		1 Lot					
	Sub-Total of 13 (13.1 to 13.3)							
14.0	**Drainage and Dewatering System**							
14.1	Drainage and Dewatering System complete in all respects as per Chapter-14 defined in Section-7 of Volume-4.		1 set					
14.2	Mandatory Spare parts as per clause 14.12 of Chapter-14 under Section-7 of Volume-4		1 Set					
14.3	Complete set of tools and instruments as per clause 14.14 of chapter-13 under section-7 of volume-4.		1 Lot					
	Sub-Total of 14 (14.1 to 14.3)							
15.0	**220V DC System**							
15.1	220V system complete with battery, battery health monitoring system, chargers and distribution boards (1 Set for Powerhouse and 1 Set for BFV		1 Lot					

Item No.	Description of Items	Make/ Country of Origin	Qty.	Unit Price (EUR)				Total Cost up to Project Site (EUR)
				Ex-works Price inclusive of packing and forwarding		Transportation Charges up to Project Site including CIP		
				(In figures)	(In Words)	(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)		(6)		(7= 4x (5+6))
	Area.) as per Chapter-15 defined in Section-7 of Volume-4.							
15.2	Mandatory Spare parts as per clause 15.12 of Chapter-15 under Section-7 of Volume-4		1 Lot					
15.3	Complete set of Tools and Instruments as per clause 15.16 of Chapter-15 under Section-7 of Volume-4.		1 Lot					
	Sub-Total of 15 (15.1 to 15.3)							
16.0	**Uninterrupted Power Supply**							
16.1	230 V AC UPS with batteries (2 sets at Powerhouse control room, 1 set at SCADA System, 1 set at DAM Gate control building, 1 set at Chaplangchhu Intake control building)		1 Lot					
16.2	Mandatory Spare parts as per clause 16.15 of Chapter-16 under Section-7 of Volume-4		1 Lot					
	Sub-Total of 16 (16.1 to 16.2)							
17.0	**Heating, Ventilation And Air Conditioning (HVAC) System**							
17.1	HVAC system complete in all respects as per Chapter-17 defined in section-7 of volume-4.		1 set					
17.2	Mandatory Spare parts as per clause 17.14 of Chapter-17 under Section-7 of Volume-4		1 Lot					
17.3	Complete set of Tools and Instruments as per clause 17.16 of Chapter-17 under Section-7 of Volume-4		1 Lot					

Item No.	Description of Items	Make/ Country of Origin	Qty.	Unit Price (EUR)				Total Cost up to Project Site (EUR)
				Ex-works Price inclusive of packing and forwarding		Transportation Charges up to Project Site including CIP		
				(In figures)	(In Words)	(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)		(6)		(7= 4x (5+6))
	Sub-Total of 17 (17.1 to 17.3)							
18.0	**Cable and Cabling System**							
18.1	Cable and cabling system complete in all respects as per Chapter-18 defined in section-7 of volume-4.		1 set					
18.2	Mandatory Spare parts as per clause 18.26 of Chapter-18 under Section-7 of Volume-4		1 Lot					
	Sub-Total of 18 (18.1 to 18.2)							
19.0	**Electric Overhead Travelling (EOT) Cranes**							
19.1	200T/40T/10T Electric Overhead Travelling Cranes for Machine Hall complete in all respects as per Chapter-19 defined in Section-7 of Volume-4.		2 Sets					
19.2	Equalizer beam, fittings, connections, electric controls and other accessories required when 200/ 40/10 tonnes EOT cranes are operating in tandem for lifting rotor		1 No.					
19.3	60T/15T Electric Overhead Travelling Crane for Butterfly Valve Cavern complete in all respects as per Chapter-19 defined in Section-7 of Volume-4.		1 Set					
19.4	10T Electric Overhead Travelling Crane for GIS Hall complete in all respects as per Chapter-7 defined in Section-19 of Volume-4.		1 Set					
19.5	Mandatory Spare parts as per clause 19.12 of Chapter-19 under Section-7 of Volume-4		1 Lot					

Item No.	Description of Items	Make/ Country of Origin	Qty.	Unit Price (EUR)				Total Cost up to Project Site (EUR)
				Ex-works Price inclusive of packing and forwarding		Transportation Charges up to Project Site including CIP		
				(In figures)	(In Words)	(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)		(6)		(7= 4x (5+6))
19.6	Complete set of Tools and Instruments as per clause 19.14 of Chapter-19 under Section-7 of Volume-4.		1 Lot					
	Sub-Total of 19 (19.1 to 19.6)							
20.0	**Fire Protection System**							
20.1	Fire Protection system complete in all respects as per Chapter-20 defined in Section-7 of Volume-4.		1 Lot					
20.2	Mandatory Spare parts as per Clause 20.24 of Chapter-20 under Section-7 of Volume-4		1 Lot					
20.3	Complete set of Tools and Instruments as per Clause 20.23 of Chapter-20 under Section-7 of Volume-4.		1 Lot					
	Sub-Total of 20 (20.1 to 20.3)							
21.0	**Fire Detection and Alarm System**							
21.1	Fire Detection & Alarm system (FDA) for entire for entire Hydro plant including GIS & pothead yard shall be as per NFPA guidelines & local statutory regulations in all respect as per Chapter 21 defined in Section-7 of Volume-4.		1 Set					
21.2	Mandatory Spare parts as per Clause 21.27 of Chapter 21 under Section-7 of Volume-4		1 Lot					
21.3	Complete set of Tools and Instruments as per Clause 21.18 of Chapter 21 under Section-7 of Volume-4.		1 Lot					

Item No.	Description of Items	Make/ Country of Origin	Qty.	Unit Price (EUR)				Total Cost up to Project Site (EUR)
				Ex-works Price inclusive of packing and forwarding		Transportation Charges up to Project Site including CIP		
				(In figures)	(In Words)	(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)		(6)		(7= 4x (5+6))
	Sub-Total of 21 (21.1 to 21.3)							
22.0	**MV Switchgear**							
22.1	MV Indoor Switchgears, Unit/Station/Service transformers, Segregated / Non-Segregated phase busduct (SPBD/NAPBD), 33/11 kV switchgear and distribution boards for complete plant as per Chapter-22 defined in section-7 of volume-4.		1 set					
22.2	Mandatory Spare parts as per clause 22.22 of Chapter-22 under Section-7 of Volume-4		1 Lot					
	Sub-Total of 21 (21.1 to 21.2)							
23.0	**LV Switchgear**							
23.1	415V switchgear and distribution boards for complete plant as per Chapter-23 defined in section-7 of volume-4.		1 Lot					
23.2	Mandatory Spare parts as per clause 23.27 of Chapter-23 under Section-7 of Volume-4		1 Lot					
23.3	Complete set of Tools and Instruments as per clause 23.23 of Chapter-23 under Section-7 of Volume-4.		1 Lot					
	Sub-Total of 23 (23.1 to 23.3)							
24.0	**Auxiliary Transformer**							
24.1	Service Transformers along with all necessary equipment & accessories, etc. for plant inhouse power distributions.		1 Lot					

Item No.	Description of Items	Make/ Country of Origin	Qty.	Unit Price (EUR)				Total Cost up to Project Site (EUR)
				Ex-works Price inclusive of packing and forwarding		Transportation Charges up to Project Site including CIP		
				(In figures)	(In Words)	(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)		(6)		(7= 4x (5+6))
	2 Nos. Station Auxiliary Transformer 33/11kV Unit Auxiliary Transformer. (4 MVA, 13.9/0.433kV- 4 Nos.) Station Auxiliary Transformer. (2.5 MVA, 11/0.433kV- 4 Nos.) Pothead yard Auxiliary Transformer (200 kVA, 11/0.433kV- 1 No.) 33kV Service Transformer, (500 KVA, 3-Ph 33 kV / 0.433kV, 4 No.) 33kV Service Transformer 200 KVA, 3-Ph, 33 kV / 0.433kV, 2 No.) Excitation transformer. (1 MVA, 13.9/0.433kV- 4 No.) as per Chapter-24 defined in Section-7 of Volume-4.							
24.2	Mandatory Spare parts as per clause 24.22 of Chapter-24 under Section-7 of Volume-4		1 Lot					
	Sub-Total of 24 (24.1 to 24.2)							
25.0	**Lighting System**							
25.1	Plant Indoor and Outdoor lighting system for entire Hydro plant including GIS & pothead yard as per Chapter-25 defined in Section-7 of Volume-4.		1 Lot					
25.2	Mandatory Spare parts as per clause 25.24 of Chapter-25 under Section-7 of Volume-4		1 Lot					
	Sub-Total of 25 (25.1 to 25.2)							

Item No.	Description of Items	Make/ Country of Origin	Qty.	Unit Price (EUR)				Total Cost up to Project Site (EUR)
				Ex-works Price inclusive of packing and forwarding		Transportation Charges up to Project Site including CIP		
				(In figures)	(In Words)	(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)		(6)		(7= 4x (5+6))
26.0	**Grounding and Lightning Protection System**							
26.1	Grounding and Lightening Protection System complete in all respects as per Chapter-26 defined in Section-7 of Volume-4.		1 Lot					
26.2	Mandatory Spares as per clause 26.12 of Chapter-26 under Section-7 of Volume-4.		1 Lot					
	Sub-Total of 26 (26.1 to 26.2)							
27.0	**Emergency Diesel Generator Set**							
27.1	Diesel Generator Set complete in all respects as per Chapter-27 defined in section-7 of volume-4.		1 Lot					
27.2	Complete set of Tools and Instruments as per clause 27.13 of Chapter-27 under Section-7 of Volume-4		1 Lot					
	Sub-Total of 27 (27.1 to 27.2)							
28.0	**Oil Handling and Purification System**							
28.1	Lubrication Oil Handling and Purification System complete in all respects as per Chapter-28 defined in Section-7 of Volume-4.		1 Set					
28.2	Mandatory Spare parts as per clause 28.13 of Chapter-28 under Section-7 of Volume-4		1 Lot					
28.3	Complete set of Tools and Instruments as per clause 28.15 of Chapter-28 under Section-7 of Volume-4.		1 Lot					

Item No.	Description of Items	Make/ Country of Origin	Qty.	Unit Price (EUR)				Total Cost up to Project Site (EUR)
				Ex-works Price inclusive of packing and forwarding		Transportation Charges up to Project Site including CIP		
				(In figures)	(In Words)	(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)		(6)		(7= 4x (5+6))
	Sub-Total of 28 (28.1 to 28.3)							
29.0	**Electrical and Mechanical Workshop Equipment**							
29.1	Electrical and mechanical workshop equipment complete in all respects as per Chapter-29 defined in Section-7 of Volume-4		1 Lot					
29.2	Mandatory Spares as per Annexure-I.		1 Lot					
	Sub-Total of 29(29.1 to 29.2)							
30.0	**Plant Communication & Public Addressing System**							
30.1	Plant communication & Public Addressing System & accessories, etc in all respect as per Chapter-30 defined in Section-7 of Volume-4.		1 Lot					
30.2	Mandatory Spare parts as per clause 30.20 of Chapter-30 under Section-7 of Volume-4		1 Lot					
	Sub-Total of 30 (30.1 to 30.2)							
31.0	**Security and Surveillance System**							
31.1	Plant communication & Public Addressing System & accessories, etc in all respect as per Chapter-31 defined in Section-7 of Volume-4.		1 Lot					
31.2	Mandatory Spare parts as per clause 31.8 of Chapter-31 under Section-7 of Volume-4		1 Lot					
31.3	Complete set of Tools and Instruments as per clause 31.9 of Chapter-31 under Section-7 of Volume-4.		1 Lot					

Item No.	Description of Items	Make/ Country of Origin	Qty.	Unit Price (EUR)				Total Cost up to Project Site (EUR)
				Ex-works Price inclusive of packing and forwarding		Transportation Charges up to Project Site including CIP		
				(In figures)	(In Words)	(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)		(6)		(7= 4x (5+6))
	Sub-Total of 31 (31.1 to 31.3)							
32.0	**Fibre Optic Communication System**							
32 .1	Fibre Optic communication system along with all necessary equipment & accessories, etc in all respect as per Chapter-32 defined in Section-7 of Volume-4.		1 Lot					
32 .2	Mandatory Spare parts as per clause 32 .58 and detailed in 32.69 of Chapter-32 under Section-7 of Volume-4		1 Lot					
32 .3	Complete set of Tools and Instruments as per clause 32 .59 of Chapter-32 under Section-7 of Volume-4.		1 Lot					
	Sub-Total of 32 (32.1 to 32.3)							
33.0	**132 kV Switchyard (ICT Bay)**							
33.1	132 kV Switch yard Bay along with all necessary equipment & accessories, etc. at Korlung Substation in all respect as per Chapter-33 defined in Section-7 of Volume-4.		1 Lot					
	Sub-Total of 33 (33.1)							
	TOTAL (1 to 33) of Price Schedule-1.1							

Note:
List for Mandatory Spares are attached as Annexure-I.

PRICE SCHEDULE-2

2.1 INSTALLATION, TESTING, COMMISSIONING (INCLUSIVE OF LOADING, TRANSPORTATION FROM SITE STORE TO PLACE OF INSTALLATION, UNLOADING), INSURANCE AND SITE STORAGE

Item No.	Description of Items	Unit	Qty.	Unit Price (BTN/INR)			Total Price (BTN/INR)
				Erection, Testing and Commissioning Charges	Insurance Charges during Storage, Erection, Testing & Commissioning	Charges for Site Storage, loading, Unloading and Transportation from store to place of Installation	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	8=4x(5+6+7)
1	Complete Turbine and Accessories as described in **Item No.1** of **Price Schedule-1.1**	Sets	4				
2	Complete Digital Governing System and Accessories as Described in **Item No. 2** of **Price Schedule-1.1**	Sets	4				
3	Complete Main Inlet Valves and Accessories as described in **Item No.3** of **Price Schedule-1.1**	Sets	4				
4	Complete Butterfly Valves and Accessories as described in **Item No.4** of **Price Schedule-1.1**	Sets	4				
5	Complete Generator and Accessories as described in **Item No.5** of **Price Schedule-1.1**	Sets	4				
6	Complete Excitation System as described in **Item No.6** of **Price Schedule-1.1**	Sets	4				
7	Complete Isolated Phase Bus Duct and Accessories as described in **Item No.7** of **Price Schedule-1.1**	Lot	1				
8	Complete Generator Transformer, ICT and Shunt Reactor as described in **Item No.8** of **Price Schedule-1.1**	Sets	17				
9	Complete 420 kV Gas Insulated Switchyard as described in **Item No. 9** of **Price Schedule-1.1**	Lot	1				

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Item No.	Description of Items	Unit	Qty.	Unit Price (BTN/INR)			Total Price (BTN/INR)
				Erection, Testing and Commissioning Charges	Insurance Charges during Storage, Erection, Testing & Commissioning	Charges for Site Storage, loading, Unloading and Transportation from store to place of Installation	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	8=4x(5+6+7)
10	Complete 420 kV and 145 kV XLPE Cables and Accessories as described in **Item No.10** of **Price Schedule-1.1**	Sets+1 Spare for each	4 +1				
11	Complete Pothead Yard Equipment as described in **Item No.11** of **Price Schedule-1.1**	Sets	1				
12	Complete Cooling Water System and Accessories as described in **Item No.12** of **Price Schedule-1.1**	Set	4				
13	Complete LP Compressed Air System as described in **Item No.13** of **Price Schedule-1.1**	Sets	2				
14	Complete Drainage and Dewatering System as described in **Item No.14** of **Price Schedule-1.1**	Lot	1				
15	Complete DC System as described in **Item No.15** of **Price Schedule-1.1**	Lot	1				
16	Complete Uninterrupted Power Supply and Accessories as Described in **Item No. 16** of **Price Schedule-1.1**	Lot	1				
17	Complete HVAC System as described in **Item No.17** of **Price Schedule-1.1**	Lot	1				
18	Complete Cables and Cabling System as described in **Item No.18** of **Price Schedule-1.1**	Lot	1				
19	Complete EOT Cranes and Accessories as described in **Item No.19** of **Price Schedule-1.1**	Lot	1				
20	Complete Fire Protection System as described in **Item No.20 of Price Schedule-1.1**	Lot	1				

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Item No.	Description of Items	Unit	Qty.	Unit Price (BTN/INR)			Total Price (BTN/INR)
				Erection, Testing and Commissioning Charges	Insurance Charges during Storage, Erection, Testing & Commissioning	Charges for Site Storage, loading, Unloading and Transportation from store to place of Installation	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	8=4x(5+6+7)
21	Complete Fire Detection and Alarm System as described in **Item No.21 of Price Schedule-1.1**	Lot	1				
22	Complete MV Switchgear as described in **Item No.22** of **Price Schedule-1.1**	Lot	1				
23	Complete LV Switch Gear as described in **Item No.23** of **Price Schedule-1.1**	Lot	1				
24	Complete Auxiliary Transformers as described in **Item No. 24** of **Price Schedule-1.1**	Lot	1				
25	Complete Lighting System as described in **Item No.25** of **Price Schedule-1.1**	Lot	1				
26	Complete Grounding and Lightning Protection System as described in **Item No. 26** of **Price Schedule-1.1**	Lot	1				
27	Complete DG Sets as described in **Item No.27** of **Price Schedule-1.1**	Lot	1				
28	Complete Lubrication Oil Handling and Purification System as described in **Item No.28 of Price Schedule-1.1**	Lot	1				
29	Complete Electrical and Mechanical Workshop Equipment as described in **Item No.29 of Price Schedule-1.1**	Lot	1				
30	Complete Plant Addressing & Public Addressing System as described in **Item No.30 of Price Schedule-1.1**	Lot	2				
31	Complete Security and Surveillance System as described in **Item No.31 of Price Schedule-1.1**	Lot	3				

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Item No.	Description of Items	Unit	Qty.	Unit Price (BTN/INR)			Total Price (BTN/INR)
				Erection, Testing and Commissioning Charges	Insurance Charges during Storage, Erection, Testing & Commissioning	Charges for Site Storage, loading, Unloading and Transportation from store to place of Installation	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	8=4x(5+6+7)
32	Complete Fibre Optic Communication System as described in **Item No.32 of Price Schedule-1.1**	Lot	4				
33	Complete 132kV Switchyard Incomer Bay for ICT Transformer as described in **Item No.33 of Price Schedule-1.1**	Lot	5				
	Total (1 to 33) of Price Schedule-2.1						

PRICE SCHEDULE-3

RECOMMENDED SPARE PARTS AND TOOLS & INSTRUMENTS

Item No.	Description	Unit	Qty.	Ex-Works Price inclusive of packing & forwarding charges Unit Rate (BTN/INR) or (EUR)	Total Ex-Works Price inclusive of packing & forwarding charges (BTN/INR) or (EUR)	Transportation Charges and inland Insurance charges upto Project Site including handling, storage & preservation and Insurance charges upto Defect Notification Period (BTN/INR) or (EUR)	Applicable Taxes/Duties/ Levies (BTN/INR) or (EUR)
1	2	3	4	5	6=4x5	7	9
TOTAL							

Total Amount in words……..)

Note:

1. The purchase of recommended Spares, Tools and Instruments etc. required during the O&M shall be exclusively at Purchaser's option.
2. List & item wise prices of the recommended spares, tools, tackles & testing equipment etc. shall be given by the bidder.
3. The Bidder shall indicate the prices in words as well as in figures.
4. This Price Schedule shall not be considered in bid evaluation

Seal/Signature of Bidder……..



ANNEXURE-I:

LIST OF MANDATORY SPARES

Item No.	Description of Items	Unit	Qty.	Unit Price (BTN/INR) or (EUR) CIP to project site		Total Price (BTN/INR) or (EUR)
				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
1.0	**Turbine and Accessories**					
1.1	Runner complete with fixing bolts.	Nos.	2			
1.2	Set of coupling bolts and keys(if applicable) runner to turbine shaft	Set	1			
1.3	Coupling bolts turbine shaft to generator shaft	Set	1			
1.4	Turbine guide bearing segments/ pads complete set	Set	2			
1.5	Set of six needle tips, gaskets, nuts & bolts, packing, etc. and renewable seat ring	Set	4			
1.6	Nozzle including needle servomotors	Set	2			
1.7	Deflector including servomotor	Set	2			
1.8	DTT (Dial Type Temp/ Thermometer) thermometer of each type	Nos.	4			
1.9	RTD (Resistance Temperature Detector) of each type	Nos.	10			
1.10	Water flow meter/ switch of each type	Nos.	2			
1.11	Pressure gauges of each type	Nos.	2			
1.12	Pressure switch / pressure transmitter of each type	Nos.	2			
1.13	Oil level gauges of each type	Nos.	2			
1.14	Valves of size 90 mm and above including penstock drain valve	No. of each Type	1			
2.0	**Digital Governor System and Accessories**					
2.1	Complete proportional valve assemblies	Nos. of each Type	2			

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Item No.	Description of Items	Unit	Qty.	Unit Price (BTN/INR) or (EUR) CIP to project site		Total Price (BTN/INR) or (EUR)
				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
2.2	Directional/Control valves (except solenoid operated)	Nos. of each Type	2			
2.3	Solenoid valve	Nos. of each Type	2			
2.4	Speed sensing device	Nos. of each Type	2			
2.5	Transducer assembly complete of all type used in the system	Nos. of each Type	1			
2.6	Printed circuit card/module	Nos. of each Type	2			
2.7	Power supply unit	Nos. of each Type	2			
2.8	Pressure oil pump-motor set	No.	1			
2.9	Jockey oil pump-motor set	No.	1			
2.10	Set of micro oil filter of each type used in the electro hydraulic actuator	Nos. of each Type	9			
2.11	Set of oil/ air filters of each type used in oil sump tank	Nos. of each Type	2			
2.12	Unloader valve complete assembly	Nos. of each Type	2			
2.13	Safety relief valve complete assembly	Nos. of each Type	2			
2.14	Coils of solenoid used in the system	Total number required for two (2) units				
2.15	Indicating lamp bulbs/ LED for each colour (Red, yellow, blue, amber etc.)	Nos. of each Type	40			
2.16	Sight glass gauges for pressure accumulator and sump tanks	Nos. of each Type	2			

Item No.	Description of Items	Unit	Qty.	Unit Price (BTN/INR) or (EUR) CIP to project site		Total Price (BTN/INR) or (EUR)
				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
2.17	Level switches, level transmitter and level indicator	Nos. of each Type	2			
2.18	Pressure switches, pressure transmitter and pressure gauges	Nos. of each Type	2			
2.19	Thermometers	Nos. of each Type	2			
2.20	Ball and roller bearing used in the pumps and motors	Nos. of each Type	2			
2.21	Complete set of gaskets, O-rings, sealing rings and packing	Nos.	2			
2.22	Nitrogen cylinders	Total number required for two (2) units				
2.26	Valves of each type (26mm and above)	Nos.	2			
3.0	**MIV and Accessories**					
3.1	Pressure oil pump motor set	No.	1			
3.2	Ball and roller bearing used in pump and motor	Nos. of each type	2			
3.3	Unloader valve complete assembly	Nos. of each type	2			
3.4	Safety relief valve complete assembly	Nos. of each type	2			
3.5	Set of Oil filters of each type used in the electro hydraulic actuator and pumping set (except pump suction filter)	Nos. of each type	4			
3.6	Level switch, level gauge and level transmitter	Nos. of each type	2			
3.7	Sight gauge assembly for accumulator and sump tank	Nos. of each type	2			

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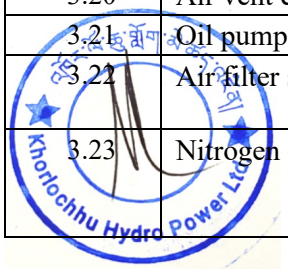
Item No.	Description of Items	Unit	Qty.	Unit Price (BTN/INR) or (EUR) CIP to project site		Total Price (BTN/INR) or (EUR)
				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
3.8	Pressure switch	Nos. of each type	2			
3.9	Thermometer	Nos. of each type	2			
3.10	Non-contact type position switches	Nos. of each type	2			
3.11	Pressure gauge	Nos. of each type	2			
3.12	Servomotor complete	No.	1			
3.13	Main inlet valve seal set each consisting of service seal and maintenance seal including fasteners and seal retainers	Sets	2			
3.14	Hydraulic bypass valve	No.	1			
3.15	Guard valve of by-pass valve	No.	1			
3.16	Set of bushes for main Trunnions	Nos.	2			
3.17	Main inlet valve body drain valve	No.	1			
3.18	Solenoid valve	Nos. of each type	2			
3.19	Solenoid Coils	Total numbers required for two (2) unit				
3.20	Air vent cum admit valve	Nos.	2			
3.21	Oil pump suction strainer/ filter set	Nos.	2			
3.22	Air filter set	Nos. of each type	2			
3.23	Nitrogen cylinders	Total nos. required for one unit				



Item No.	Description of Items	Unit	Qty.	Unit Price (BTN/INR) or (EUR) CIP to project site		Total Price (BTN/INR) or (EUR)
				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
3.24	Complete proportional valve assemblies	Nos. of each type	2			
3.25	Control valves	Nos. of each type	2			
3.26	Transducers assemblies complete of all type used in the system	Nos.	2			
3.27	Valves of each type (26mmm and above)	Nos.	2 each			
4.0	**BFV and Accessories**					
4.1	Pressure oil pump motor set	No.	1			
4.2	Ball and roller bearing used in pump and motor	Nos. of each type	2			
4.3	Un-loader valve complete assembly	No. of each type	1			
4.4	Safety relief valve complete assembly	No. of each type	1			
4.5	Set of Oil filters of each type used in the electro hydraulic actuator and pumping set (except pump suction filter)	Nos. of each type	2			
4.6	Level switch, level gauge and level transmitter	No. of each type	1			
4.7	Sight gauge assembly for accumulator and sump tank	No. of each type	1			
4.8	Pressure switch	No. of each type	1			
4.9	Thermometer	No. of each type	1			
4.10	Non-contact type position switches	set	1			

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Item No.	Description of Items	Unit	Qty.	Unit Price (BTN/INR) or (EUR) CIP to project site		Total Price (BTN/INR) or (EUR)
				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
4.11	Pressure gauge	No. of each type	1			
4.12	Servomotor complete	No.	1			
4.13	Butterfly valve seal set each consisting of service seal and maintenance seal including fasteners and seal retainers	sets	2			
4.14	Hydraulic bypass valve	No.	1			
4.15	Guard valve of by-pass valve	No.	1			
4.16	Set of bushes for main Trunnions	Nos.	2			
4.17	Butterfly valve body drain valve	No.	1			
4.18	Solenoid valve	Nos. of each type	2			
4.19	Solenoid Coils	Total numbers required for two (2) units				
4.20	Air vent cum admit valve	No.	1			
4.21	Oil pump suction strainer/ filter set	Nos.	2			
4.22	Air filter set	Nos. of each type	2			
4.23	Nitrogen cylinders	Total nos. required for one unit				
4.24	Complete proportional valve assemblies	No. of each type	1			
4.25	Control valves	No. of each type	1			
4.26	Transducers assemblies complete of all type used	No.	1			

Item No.	Description of Items	Unit	Qty.	Unit Price (BTN/INR) or (EUR) CIP to project site		Total Price (BTN/INR) or (EUR)
				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
4.27	Valves of each type (26mm and above)	No. of each type	1			
5.0	**Generator and Accessories**					
5.1	Stator coils of each type installed, including associated installation materials, sLot packing, wedges, ripples springs, tape, end winding support blocks, bracing components, corona protectiontaes with varnish, other associated winding and insulation material – half of each type installed to wind on generator.	Set	1			
5.2	Rotor poles and all necessary installation	Nos.	12 (6 nos. shoe with coil and 6 nos. coil)			
5.3	Generator air/water cooler	Set	2			
5.4	Brush holders for generator sliprings	Set	4 set of all types used			
5.5	Brushes for generator sliprings	Set	12			
5.6	Toothed wheel speed signal generator sensor and transducer	Set	2			
5.7	Brush holder service kit	Set	2			
5.8	Brush holder set for shaft voltmeter	Set	2			
5.9	Brushes for shaft voltmeter	Set	2			

Item No.	Description of Items	Unit	Qty.	Unit Price (BTN/INR) or (EUR) CIP to project site		Total Price (BTN/INR) or (EUR)
				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
5.10	O-rings, packings, gaskets and seals – of each make and type installed	Set	10			
5.11	Brake shoes	Set	2			
5.12	Brake/jack unit	Set	2			
5.13	Brake/jack cylinder rings, packing, seals, etc of each make and type installed	Set	5			
5.14	Brake/jack control valves-of each make and type installed	Set	5			
5.15	Hydraulic hoses – of each make and type installed	Set	5			
5.16	Jacking oil pump – motor set	Set	1			
5.17	Bearing pads.	Set	1 complete set			
5.18	Temperature, level, pressure and flow relays – of each type installed	Set	2			
5.19	Indicating instrument including associated transducers - of each type installed	Set	2			
5.20	RTDs - of each type installed	Set	5			
5.21	Thrust block with thrust ring (key)	Set	1			
5.22	Bearing oil coolers for Thrust bearing and Lower guide bearing	Nos.	4 in case plugin type or 1 set in case of submerged			

Item No.	Description of Items	Unit	Qty.	Unit Price (BTN/INR) or (EUR) CIP to project site		Total Price (BTN/INR) or (EUR)
				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
			/outside			
5.23	AC & DC Pump & Motor for high pressure lubrication system	Set	1			
5.24	Each DTT, RTD, Pressure indicator switches, Flow indicator meters & switches ,level indicator switch ,	Nos. of Each type	2			
5.25	Valves	Nos. of Each type	2			
5.26	Probes for Air gap and Vibration and any other parameters Monitoring Purpose	Nos. of Each type	2			
5.27	Coupling capacitor for Partial Discharge monitoring purpose	Set	1			
6.0	**Excitation System**					
6.1	Electronic cards pertaining to the AVR, comprising one (1) piece of every kind, type or size.	Sets	2			
6.2	Electronic modules not included in the AVR but necessary for the control of the thyristor circuits	Sets	2			
6.3	Excitation Transformer complete with all accessories	No.	1			
6.4	Rectifier cooling fan complete with motor and all accessories	Set	1			
6.5	Thyristors bridge complete with fuses and all accessories	Sets	2			
6.6	Field breaker with all accessories	No.	2			
6.7	Field breaker operating coils (trip and closing coils)	Sets	3			
6.8	Field flashing rectifier	Sets	2			
6.9	Field flashing breaker with all accessories	Nos.	2			
6.10	Field flashing breaker operating coils (trip and closing coils)	Sets	3			

Item No.	Description of Items	Unit	Qty.	Unit Price (BTN/INR) or (EUR) CIP to project site		Total Price (BTN/INR) or (EUR)
				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
6.11	Ancillary Relays, circuit breakers, contactors, switches, indications, etc.	Sets	2			
6.12	Power pack (consisting of AC/DC and DC/DC convertor) of each type	Sets	2			
6.13	Blown fuse detectors	Set	1			
6.14	Fuses of each type used	Sets	3			
6.15	Auxiliary transformer/Control Transformers	No. each type used	1			
6.16	Blocking diodes for field	Sets	2			
6.17	Fans with its accessories	Nos.	6			
6.18	HMI Module	No.	1			
7	**IPBD**					
7.1	Bidder to Quote the Required SPARE PARTS for successful commissioning	Lot	1			
8	**Generator Transformers, ICT and Shunt Reactor**					
8.1	HV Bushing	Nos. of each type & rating	3			
8.2	LV Bushing	Nos. of each type & rating	3			
8.3	Neutral bushing	Nos. of each type & rating	3			
8.4	Oil cooler pumps with motor (complete assembly)	Nos. of each type & rating	2			

Item No.	Description of Items	Unit	Qty.	Unit Price (BTN/INR) or (EUR) CIP to project site		Total Price (BTN/INR) or (EUR)
				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
8.5	Bearing for Oil circulation pump	Nos. of each type & rating	3			
8.6	Buchholz relay complete (main tank)	Nos. of each type & rating	2			
8.7	Local Winding temperature indicator	Nos. of each type & rating	2			
8.8	Remote winding temperature indicator with sensing device and matching unit	Nos. of each type & rating	2			
8.9	Oil temperature indicator	Nos. of each type & rating	2			
8.10	Pressure relief device	Nos. of each type & rating	2			
8.11	Magnetic oil level gauge	Nos. of each type & rating	2			
8.12	Set of Valves	Nos. of each size and type	2			
8.13	Set of starters, contactors, relays and switches for electrical control panel	Nos. of each type & rating	2			
8.14	Remote tap position indicator	No. of each type & rating	1			
8.15	Oil flow indicator	Sets of each type & rating	2			
8.16	Terminal connector	Sets of each type & rating	2			
8.17	Aircel	Nos. of each type & rating	2			
8.18	Gaskets for Bushings, flanges, manholes	Sets of each type & rating	2			

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				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
8.19	Insulating oil	Quantity of oil (20% in case imported oil is used)	10%			
9.0	**Gas Insulated Switchgear (GIS)**					
9.1	General Spares					
i)	Cable Connection Enclosure with the main Circuit (if applicable)	No. of each Type	1			
ii)	SF6 gas Pressure Relief Devices of each type along with O-rings	Sets of each Type	2			
iii)	SF6 Pressure gauge cum switch OR Density monitors and pressure switch, as applicable, of each type	Total population (max 5 nos. and min. 1 no.)	5%			
iv)	Coupling device of each type for pressure gauge cum switch for connecting Gas handling plant	Sets of each Type	2			
v)	Rubber Gaskets, “O” Rings and Seals for SF6 gas of each type	Sets of each Type	3			
vi)	Molecular filter for SF6 gas with filter bags	Total weight	5%			
vii)	All types of Control Valves for SF6 gas of each type	Nos. of each Type	3			
viii)	SF6 gas	Total gas quantity	20%			

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(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
ix)	Locking device to keep the Dis-connectors (Isolators) and Earthing switches in close or open position in case of removal of the driving Mechanism	Nos. of each Type	3			
x)	Spare EHV Cable of longest phase of a feeder as applicable (if applicable)	Run (1-phase)	1			
xi)	Spares for local control cabinet including MCB, Fuses, Timers, Aux. relays, Contactor, Push Buttons, Switches, Lamps, Annunciation Windows etc. of each type & rating and terminal of each type	Sets of each Type	2			
xii)	HV Cable Termination kit of each type (if applicable)	Sets of each Type	2			
xiii)	HV Cable Jointing kit of each type (if applicable)	No. of each Type	1			
xiv)	UHF PD Sensors of each type	Total population (max 5 Nos. and min. 1 No.)	5%			
xv)	Support Insulator/Gas Barrier of each type along with associated contacts and shields	Nos. of each Type	5			
xvi)	SF6 to air bushing of each type & rating along with conductor and enclosure	No. of each Type	1			
xvii)	SF_6 Gas Filling Kit(Hose, valve adaptors, regulator)	complete set	1			
xviii)	Gas Sampling Port Adapter and Gas Filters (Moisture/Particle)	Set	1			
xix)	Partial Discharge Sensors (UHF/VHF) -Online condition monitoring	Set	1			
xx)	Local Monitoring Display Unit -HMI panel for GIS	Set	1			

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				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
xxi)	GIS Alignment Tool Kit-OEM-specific torque tools, alignment jigs	Full kit	1			
9.2	SF6 Circuit Breaker:					
i)	Complete Circuit Breaker (1 phase unit) of each type & rating complete with interrupter, main circuit, enclosure and Marshalling Box with operating mechanism to enable replacement of any type/rating of CB by spare (as applicable) (Applicable for CB without PIR)	Set of each Type	1			
ii)	Trip coil assembly with resistor as applicable,	Sets of each Type	2			
iii)	Closing coil assembly with resistor as applicable,	Sets of each Type	2			
iv)	Grading Capacitor	Nos.	3			
v)	Rubber gaskets, 'o' rings and seals	Set of each Type	1			
vi)	Molecular filter	Nos.	2			
vii)	Density/Pressure monitoring systems	No.	1			
viii)	SF6 Gas	Total used quantity in substation	15%			
ix)	Relays, Power contactors, push buttons, timers & MCBs etc. of each type and rating	Set of each Type	1			
x)	Auxiliary switch assembly,	Sets of each Type	2			
xi)	Operation Counter	Sets of each Type	2			

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				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
xii)	Window scope/ Observing window,	Sets of each Type	2			
xiii)	LOTO arrangement provision	Set of each type	1			
9.3	For Hydraulic Operated Mechanism, if applicable					
i)	Hydraulic operating mechanism with drive motor of each type	Set of each Type	1			
ii)	Ferrules, joints and couplings of each type	Set of each Type	1			
iii)	Hydraulic filter of each type	Set of each Type	1			
iv)	Hose pipe of each type	Set of each Type	1			
v)	N2 Accumulator of each type	Set of each Type	1			
vi)	Valves of each type including Safety valve if	Set of each Type	1			
vii)	Valves of each type	Set of each Type	1			
viii)	Pipe length (copper & steel) of each size & type	Set of each Type	1			
ix)	Pressure switches of each type	Set of each Type	1			
x)	Pressure gauge with coupling device of each type	Set of each Type	1			
xi)	Hydraulic oil	20% of total qty. used				

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(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
xii)	Pressure Relief Device of each type	Set of each Type	1			
xiii)	Spring Charging Motor with Limit switch	Nos. of each Type	2			
9.4	For Spring Operated Mechanism, if applicable					
i)	Complete Spring Operating Mechanism including charging mechanism etc. of each type	Set of each Type	1			
ii)	Spring Charging Motor	Nos. of each Type	2			
9.5	ISOLATORS					
i)	Complete set of 3 nos. of single phase / one 3-phase isolator of each type, dimension, current & voltage rating including main circuit, enclosure, driving mechanism and support Insulator etc. to enable replacement of any type/rating of Isolator by spare	Set of each Type	1			
ii)	3 No. of single phase / one no of 3-phase Maintenance Earthing switch of each type, dimension, current & voltage including main circuit, enclosure, driving mechanism and support Insulator etc. to enable replacement of any type/rating of Earth Switch by spare	Set of each Type	1			
iii)	3 No. of single phase / one no of 3-phase Fast Earthing switch of each type, dimension, current & voltage rating including main circuit, enclosure, driving mechanism and support Insulator etc. to enable replacement of any type/rating of Earth Switch by spare (if applicable)	Set of each Type	1			
iv)	Copper contact fingers for isolator male & female contact along with corona shield– for one complete (3 phase) isolator of each type and rating	Set of each Type	1			

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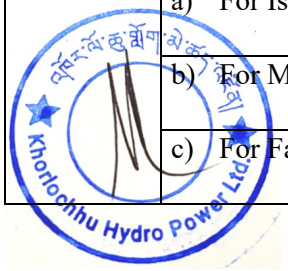
				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
v)	Copper contact fingers for Maintenance Earthing switch male & female contacts along with corona shield, for one complete (3 phase) earthing switch of each type and rating	Set of each Type	1			
vi)	Isolator Arms with finger contacts and current carrying assembly	Set	1			
vii)	Copper contact fingers for Fast Earthing switch male & female contacts along with corona shield, for one complete (3 phase) earthing switch of each type and rating (if applicable)	Set of each Type	1			
viii)	Open / Close contactor assembly, timers, key interlock, interlocking coils, relays, push buttons, indicating lamps Power contactors, resistors, fuses, MCBs & drive control cards etc. for one complete MOM box (3 – phase gang operated or 1 – phase unit) dis-connector and (3 phase) earthing switch of each type and rating					
	a) For Isolator	Set of each Type	1			
	b) For Maintenance Earth switch	Set of each Type	1			
	c) For Fast Earthing Switch (if applicable)	Set of each Type	1			
ix)	Limit switch and Aux. Switches for complete 3 phase equipment					
	a) For Isolator	Sets of each Type	2			
	b) For Maintenance Earth switch	Sets of each Type	2			
	c) For Fast Earthing Switch (if applicable)	Sets of each Type	2			



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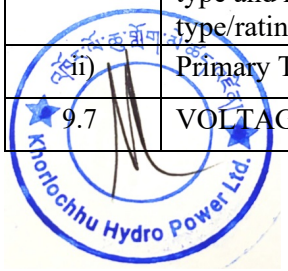
				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
x)	Drive Mechanism of each type					
	a) For Isolator	No. of each Type	1			
	b) For Maintenance Earth switch	No. of each Type	1			
	c) For Fast Earthing Switch (if applicable)	No. of each Type	1			
xi)	Motor for Drive Mechanism of each type					
	a) For Isolator	Nos. of each Type	3			
	b) For Maintenance Earth switch	Nos. of each Type	3			
	c) For Fast Earthing Switch (if applicable)	Nos. of each Type	3			
xii)	Mechanical Interlock Devices interlock for earth switch and isolator	Set Each Type	1			
xiii)	LOTO arrangement provision	Set Each Type	1			
9.6	CURRENT TRANSFORMER					
i)	Complete CT with Terminal connector & structure of each type and rating with enclosure to enable replacement of any type/rating of CT by spare	No. of each Type	1			
ii)	Primary Terminal Bushing	Sets	2			
9.7	VOLTAGE TRANSFORMER					



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				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
i) 9.7.1	Complete VT with Terminal connector & structure of each type and rating with enclosure to enable replacement of any type/rating of VT by spare (if applicable)	No. of each Type	1			
9.8	SURGE ARRESTOR					
i)	Gas insulated SA for of each type and ratings enclosure & surge monitor counter to enable replacement of any type/rating of Gas Insulated SA by spare (if applicable)	No. of each Type	1			
ii)	Surge counter/ monitor of each rating and type	No. of each Type	1			
9.9	Oil to SF6 bushing for Transformer/Reactor as applicable of each rating	No. of each Type	1			
9.10	Oil to Cable Termination kit for Transformer as applicable of each rating	Nos. of each Type	2			
9.11	Controlled Switching Device along with Transducers, Sensors, Contactors, Switches etc.	Set of Each type	1			
10.0	**420 kV and 145kV XLPE Cables**					
10.1	Control cables	Total Qty for each type of cable	5%			
10.2	Signal cables	Total Qty for each type of cable	5%			
10.3	EHV & HV Cable Termination kit of each type (if applicable)	Sets of each Type	2			

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				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
10.4	EHV & HV Cable Jointing kit of each type (if applicable)	No. of each Type	1			
10.5	Lugs of each size	Nos. of each type used	100			
11.0	**Pothead Yard Equipment**					
11.1	Disc Insulators	Total number of discs of each voltage class installed at the substation/switchyard.	5%			
11.2	Long Rod Insulator	Total number of insulators of each voltage class installed at the substation/switchyard, subject to a minimum number of three insulators of each voltage class.	5%			

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(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
11.3	Conductor accessories and hardware	Quantity shall be commensuration with the spare for conductor and insulators.				
11.4	Complete Potential Transformer / Capacitor Voltage Transformer with terminal connectors & structure	Nos. of each rating	2			
11.5	SURGE ARRESTOR Complete Surge Arrester with insulating base and Terminal connector & structure	Nos. of each rating	2			
11.6	POST INSULATOR	Nos. for each voltage rating	3			
11.7	DOUBLE BREAK ISOLATORS					
i)	One complete pole including support Insulator, motor operating mechanism and terminal connector but excluding structure	Two (2) complete isolators of each voltage class, and highest short-time and normal current rating (along with support structure)	2			

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				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
		available at any of the substations				
ii)	Isolator Arms with finger contacts and current carrying assembly	set	1			
iii)	Support Insulators	set	1			
iv)	Copper contact fingers for male & female contacts	set	2			
v)	Open / Close contactor assembly, timers, key interlock push button switch & auxiliary switches	set	2			
vi)	Limit switch	sets	2			
vii)	Motor housing bearing assembly	No.	1			
viii)	Terminal Pads and connectors	sets	2			
ix)	Motor with gear assembly and bevel gear assembly	No.	1			
x)	Corona shield rings	Nos.	3			
xi)	Hinge pins	Nos.	3			
xii)	Bearings	Set	1			
xiii)	Interlocking coil with resistor	Nos.	5			
xiv)	Fuses of each rating	Nos.	5			
12.0	**Cooling Water System**					
12.1	Cooling water pump					
i)	Complete pump with motor	No.	1			

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				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
ii)	Impeller	Nos.	3			
iii)	Wear rings set	Nos.	3			
iv)	xv) Pump mechanical seal	Nos.	2			
v)	Motor bearings	Nos.	3			
vi)	Pump bearings	Nos.	3			
vii)	Set of seal and gasket for pump	Nos.	2			
12.2	Strainer					
i)	Set of complete wire filter element assembly as per design	Nos.	2			
ii)	Heat Exchanger	No.	1			
iii)	Gaskets of heat exchanger	Nos. each	20			
iv)	Valves of size 90 mm and above	Nos. of each type	2			
v)	Pressure gauges and pressure switches	Nos. of each type	2			
vi)	Flow meters and flow switches	Nos. of each type & size	2			
vii)	Temperature gauges and temperature transmitter	Nos. of each type & size	2			
viii)	Motorized valves of each type along with motor/ panel and other accessories	Nos. of each type & size	2			
13.0	**LP Compressed Air System**					

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				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
13.1	Air dryer complete assembly	No.	1			
13.2	Safety valves	No. of each type	1			
13.3	Pressure gauge, pressure switch and pressure transducer	No. of each type	1			
13.4	Temperature gauge and temperature switch	No. of each type	1			
13.5	Oil and air filter	Nos. of each type	2			
13.6	Automatic moisture trap	Nos. of each type	2			
13.7	Solenoid and directional valve	No. of each type	1			
13.8	Standard gasket/ O- ring/packing kit for compressor	Nos.	4			
13.9	Valves DN15 and above	Nos. of each type	2			
13.10	Belts	Nos. of each type	2			
14.0	**Drainage & Dewatering System**					
14.1	Submersible pumps for powerhouse drainage system					
i)	Complete submersible pump–motor set	No.	1			
ii)	Complete set of pump shaft seal including mechanical seal	Nos. of each type	2			
iii)	Complete set of wearing rings, O-rings and gaskets	Nos.	2			

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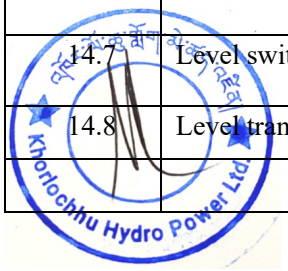
				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
iv)	Submersible cable (length to be mentioned by the Contractor)	Length	1			
14.2	Submersible pump for oil-water sump					
i)	Complete submersible pump–motor set	No.	1			
ii)	Complete set of pump shaft seal including mechanical seal	Nos. of each type	2			
iii)	Complete set of wearing rings, O-rings and gaskets	Nos. of each type	2			
iv)	Submersible cable (length to be mentioned by the Contractor)	Length of each type.	1			
14.3	Submersible pump for Drainage of cooling water pit					
i)	Complete submersible pump–motor set	No.	1			
ii)	Complete set of pump shaft seal including mechanical seal	Nos. of each type	2			
iii)	Complete set of wearing rings, O-rings and gaskets	Nos.	2			
iv)	Submersible cable (length to be mentioned by the Contractor)	Length	1			
14.4	Pressure switches	No. of each type	1			
14.5	Valves of each type 90mm and above	No.	1			
14.6	Pressure gauges	No. of each type	1			
14.7	Level switches	No. of each type.	1			
14.8	Level transducer of each type	No.	1			



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				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
15.0	**DC Supply System**					
15.1	220 Battery					
i)	Spare cell (complete) for each 220 V type and size used.	Nos.	10			
ii)	Insulators for racks in percentage of total quantity used for 220 V battery set in percentage of total quantity of each type used.	(Percentage)	10%			
iii)	Inter cell Connectors suitable for making connections for 220 V of each size used.	Nos.	20			
iv)	Connectors suitable for making connections for 220 V each size of cable to the battery terminals.	Nos.	5			
v)	Vent Plugs, caps of each type, Connecting Bolts/Connectors of each type used for 220 V.	Nos.	10			
vi)	Fuses of each size used in 220 V System	Sets	2			
vii)	Electrolyte used in percentage of total quantity used for each 220 V System in power house & switchyard	(Percentage)	10%			
15.2	Battery Chargers					
i)	Electronic circuit board cards of each type used.	No	1			
ii)	MCCB of each type/rating used	Nos.	1			
iii)	Air Circuit breaker of each type/rating used	Nos.	1			
iv)	Blocking diode assembly of each type/rating used	Nos.	2			
v)	Rectifier transformer (Dry type) and choke of each type/rating used	Nos.	1			
vi)	Silicon Controlled Rectifier/Complete Thyristor Bridge/ Module of each type/rating used	Nos.	4			
vii)	DC Voltmeter of each type/rating used	Nos.	2			

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				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
viii)	DC Ammeter of each type/rating used	Nos.	2			
ix)	Shunt Resistor of each type/rating used	Nos.	2			
x)	Contactor of each type/rating used	Nos.	1			
xi)	Selector switch of each type/rating used	Nos.	2			
xii)	Indicating lamps of each colour with lamp covers used in each charger	Nos.	5			
xiii)	Trip element of each size/type used	Nos.	1			
xiv)	HRC fuses (Auxiliary Fuse of each type/size/rating used)	Nos.	3			
xv)	Heat sink for SCR of each type/size/rating used	Nos.	3			
xvi)	Semi Conducting Type Fast Fuse of each type/rating used	Nos.	6			
15.3	Main and Sub DC Distribution Boards					
i)	MCCB of each rating/type with door operating handle in percentage of total quantity used. Minimum one number shall be supplied if the percentage is in fraction.	(Percentage)	10%			
ii)	Contactors of each rating and type used	Nos.	2			
iii)	Indicating lamps with lamp covers of each type used	Nos.	4			
iv)	Terminal blocks	Nos.	10			
v)	Selector switch of each type and rating used	Nos.	2			
vi)	Indicating instruments with transducers of each type /rating used	Nos.	2			
vii)	Trip element of each type/size used	Nos.	2			
viii)	Relay of each type and rating used	Nos.	1			

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				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
ix)	HRC fuses of each type/size used	Nos.	3			
x)	Sensors, transducers etc. of each type and rating used	Nos.	1			
16.0	**Uninterrupted Power Supply**					
16.1	MCB/MCCB of each rating	Nos. of each type and rating	2			
16.2	Semiconductor fuses of each rating	Nos. of each type and rating	2			
16.3	Control cards	Nos. of each type and rating	2			
16.4	Thyristors / Power Transistors of each rating	Nos. of each type and rating	2			
16.5	Power diodes of each rating	Nos. of each type and rating	2			
16.6	Auxiliary relays & Power contactors of each type.	Nos. of each type and rating	2			
16.7	Filter capacitors	Nos. of each type and rating	2			

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(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
16.8	Filter choke	Nos. of each type and rating	2			
16.9	Fuses	Nos. of each type and rating	2			
16.10	CT and PT	Nos. of each type and rating	2			
17.0	**Heating, Ventilation And Air Conditioning (HVAC) System**					
17.1	Motor Bearing	No. of each type	1			
17.2	Safety valves	No. of each type	1			
17.3	Pressure gauge, pressure switch and pressure transducer	No. of each type	1			
17.4	Temperature gauge and temperature switch	No. of each type	1			
17.5	Filter element	Nos. of each type	2			
17.6	Air Grills	Nos. of each type	2			
17.7	Pump Impellers	Nos. of each type	2			
17.8	Pipes & Tubes	RMT each type	2			

Item No.	Description of Items	Unit	Qty.	Unit Price (BTN/INR) or (EUR) CIP to project site		Total Price (BTN/INR) or (EUR)
				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
17.9	Solenoid and directional valve	No. of each type	1			
17.10	Standard gasket/ O- ring/packing kit for compressor	Nos.	4			
17.11	Valves DN15 and above	Nos. of each type	2			
17.12	Belts	Nos. of each type	2			
17.13	expansion valve	Nos.	2			
17.14	Motors	No. of each type	1			
18.0	**Cables and Cabling System**					
18.1	Control cables	Total Qty for each type of cable	5%			
18.2	Signal cables	Total Qty for each type of cable	5%			
18.3	420kV & 145kV XLPE Cable Termination kit of each type (if applicable)	Sets of each Type	2			
18.4	420kV & 145kV XLPE Cable Jointing kit of each type (if applicable)	No. of each Type	1			
18.5	Lugs of each size	Nos. of each type used	100			

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				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
19.0	**Electric Overhead Travelling (EOT) Cranes**					
19.1	**Electric Overhead Travelling (EOT) Cranes**					
i)	**Power House EOT Crane**					
a)	Main Hoist					
•	Wire rope	Full length	1			
•	Set of brake lining, pad, motor, springs, seal kit, solenoid coil etc. complete with rivets etc. for each type of brake supplied	No.	1			
•	Electric motor	No. of each type	1			
•	Limit switches	No. of each type	1			
b)	Auxiliary Hoist					
•	Wire rope	Full length	1			
•	Set of brake lining, pad, motor, springs, seal kit, solenoid coil etc. complete with rivets etc. for each type of brake supplied	No.	1			
•	Electric motor	No. of each type	1			
•	Limit switches	No. of each type	1			
c)	Bridge drive					
•	Electric motor	No. of each type	1			
•	Set of brake lining, pad, motor, springs, seal kit, solenoid coil etc. complete with rivets etc. for each type of brake supplied.	Nos.	2			

Item No.	Description of Items	Unit	Qty.	Unit Price (BTN/INR) or (EUR) CIP to project site		Total Price (BTN/INR) or (EUR)
				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
•	Limit Switches	No. of each type	1			
d)	Trolley drive					
•	Set of brake lining, pad, motor, springs, seal kit, solenoid coil etc. complete with rivets etc. for each type of brake supplied	No.	1			
•	Electric motor	No. of each type	1			
•	Limit Switches	No. of each type	1			
e)	Monorail					
•	Wire rope	Full length	1			
•	Electric motor	No. of each type	1			
•	Limit switches	No. of each type	1			
•	Set of brake lining, pad, motor, springs, seal kit, solenoid coil etc. complete with rivets etc. for each type of brake supplied	No.	1			
f)	Other miscellaneous spares for complete crane including monorail:					
•	Circuit breaker of each type	No.	1			
•	Printed circuit boards (with components)	No. of each type	1			
•	Fuses including fast acting fuses used in thyristor circuits	Nos. of each type	2			
•	Indicating lamps/ LED	Nos. of each colour (red, blue, green,	2			

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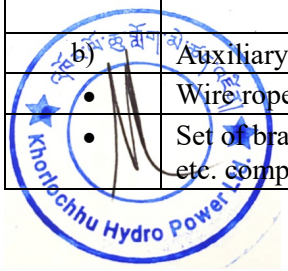
Item No.	Description of Items	Unit	Qty.	Unit Price (BTN/INR) or (EUR) CIP to project site		Total Price (BTN/INR) or (EUR)
				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
		amber, white etc.)				
•	Overload relays and time delay relay	No. of each type	1			
•	Bearings for wheels, gear boxes, hooks, hoist drum and motors, for complete crane	No. of each type and size	1			
•	Push button	Nos. of each colour amber, white etc.) (red, blue, green)	2			
•	Module (Rectifier/ MOSFET/Thyristor)	No. for each MH, AH, CT and LT	1			
ii)	**Butterfly Valve House Cavern EOT Crane**					
a)	Main hoist					
•	Wire rope	Full length	1			
•	Set of brake lining, pad, motor, springs, seal kit, solenoid coil etc. complete with rivets etc. for each type of brake supplied	No.	1			
•	Electric motor	No. of each type	1			
•	Limit switches	No. of each type	1			
b)	Auxiliary hoist					
•	Wire rope	Full length	1			
•	Set of brake lining, pad, motor, springs, seal kit, solenoid coil etc. complete with rivets etc. for each type of brake supplied	No.	1			



Item No.	Description of Items	Unit	Qty.	Unit Price (BTN/INR) or (EUR) CIP to project site		Total Price (BTN/INR) or (EUR)
				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
•	Electric motor	No. of each type	1			
•	Limit switches	No. of each type	1			
c)	Bridge drive					
•	Electric motor	No. of each type	1			
•	Set of brake lining, pad, motor, springs, seal kit, solenoid coil etc. complete with rivets etc. for each type of brake supplied	Nos.	2			
•	Limit Switches	No. of each type	1			
d)	Trolley drive					
•	Set of brake lining, pad, motor, springs, seal kit, solenoid coil etc. complete with rivets etc. for each type of brake supplied	No.	1			
•	Electric motor	No. of each type	1			
•	Limit Switches	No. of each type	1			
e)	Other miscellaneous spares for complete crane;					
•	Circuit breaker of each type	No.	1			
•	Printed circuit boards (with components)	No. of each type	1			
•	Fuses including fast acting fuses used in thyristor circuits	Nos. of each type	2			
•	Indicating lamps/ LED	Nos. of each colour (red, blue, green,	2			

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Item No.	Description of Items	Unit	Qty.	Unit Price (BTN/INR) or (EUR) CIP to project site		Total Price (BTN/INR) or (EUR)
				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
		amber, white etc.)				
•	Overload relays and time delay relay	No. of each type	1			
•	Bearings for wheels, gear boxes, hooks, hoist drum and motors for complete crane	No. each type and size	1			
•	Push button	Nos. of each colour (red, blue, green, amber, white etc.)	2			
•	Module (Rectifier/ MOSFET/Thyristor)	No. for each MH, CT and LT	1			
iii)	**GIS EOT Crane**					
a)	Hoist					
•	Wire rope	Full length	1			
•	Set of brake lining, pad, motor, springs, seal kit, solenoid coil etc. complete with rivets etc. for each type of brake supplied	No.	1			
•	Electric motor	No. of each type	1			
•	Limit switches	Nos. of each type	1			
b)	CT and LT motion					
•	Electric motor	No. of each type	1			
•	Set of brake lining, pad, motor, springs, seal kit, solenoid coil etc. complete with rivets etc. for each type of brake supplied	Nos.	2			

Item No.	Description of Items	Unit	Qty.	Unit Price (BTN/INR) or (EUR) CIP to project site		Total Price (BTN/INR) or (EUR)
				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
•	Limit Switches	No. of each type	1			
c)	Other miscellaneous spares for complete crane:					
•	Circuit breaker of each type	No.	1			
•	Printed circuit boards (with components)	No. of each type	1			
•	Fuses including fast acting fuses used in thyristor circuits	Nos. of each type	2			
•	Indicating lamps/LED	Nos. of each colour (Red, blue, green, amber, white etc.)	2			
•	Overload relays and time delay relay	No. of each type	1			
•	Bearings for wheels, gear boxes, hooks, hoist drum and motors for complete crane	No. each type and size	1			
•	Push button	Nos. of each colour (Red, blue, green, amber, white etc.)	2			
•	Module (Rectifier/MOSFET/Thyristor)	No. for each hoist and cross travel	1			
20.0	**Fire Detection & Alarm System**					

Item No.	Description of Items	Unit	Qty.	Unit Price (BTN/INR) or (EUR) CIP to project site		Total Price (BTN/INR) or (EUR)
				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
20.1	Manual call points	Nos of Each Type	3			
20.2	Multi sensor detector	Nos of Each Type	3			
20.3	Beam detector	Nos of Each Type	3			
20.4	Digital LHS cable	Total Qty	10%			
20.5	Addressable Rate of rise of temperature detector	Nos of Each Type	3			
20.6	Addressable Interface Unit	Nos of Each Type	3			
20.7	Electronic Hooters	Nos of Each Type	3			
20.8	QBD (Quartzoid bulb detector)	Nos of Each Type	10			
20.9	Cables	Total Qty	10%			
21.0						
21.1	Automatic fire detectors, manual call points & response indicators, smoke detectors.	Total numbers supplied for each type with minimum 2 Nos	10%			
21.2	Signal distribution modules, signal conditioning modules and input/output modules	Each type of Module or minimum	10%			

Item No.	Description of Items	Unit	Qty.	Unit Price (BTN/INR) or (EUR) CIP to project site		Total Price (BTN/INR) or (EUR)
				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
		one, whichever is higher.				
21.3	Processor module, communication module, power supply module, memory module and any other module.	Each type of Module or minimum one, whichever is higher	10%			
21.4	Push buttons, indicators, indicating lamps, selector switches relays.	Each type of Module or minimum one, whichever is higher.	10%			
21.5	Connectors for prefab cables – male & female end	No. in each type	2			
21.6	Field instruments, transmitters, limit switches, Proximity switches, interposing relay, MCB, relay, timer or any other instrument / item supplied.	Each type of Module or minimum one, whichever is higher	10%			
21.7	Fuses of each type & rating	Nos or 30% whichever is higher.	2			
21.8	Terminals of each type	Nos.	10			
21.9	Coils, gaskets, diaphragm, o' rings	No. of each type and size	1			

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Item No.	Description of Items	Unit	Qty.	Unit Price (BTN/INR) or (EUR) CIP to project site		Total Price (BTN/INR) or (EUR)
				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
21.10	Plunger, seat	No. of each type and size	1			
22.0	**MV Indoor Switchgear**					
22.1	Breaker Close Coil	Nos of each type & rating	2			
22.2	Breaker Trip Coil	Nos of each type & rating	2			
22.3	Breaker Spring Charge Motor	Nos of each type & rating	2			
22.4	Current Transformer	Set of each type & rating	1			
22.5	Voltage transformer	Set of each type & rating	1			
22.6	HT Fuses	Set of each type & rating	3			
22.7	Gas Filling device Kit	Set	1			
22.8	MCB/MCCB	Nos of each type & rating	5			
22.9	Indication Lamps	Nos of each type & rating	10			
22.10	Protection relay	No of each type & rating	1			
22.11	Meters	No of each type & rating	1			
22.12	Push button	No of each type & rating	5			

Item No.	Description of Items	Unit	Qty.	Unit Price (BTN/INR) or (EUR) CIP to project site		Total Price (BTN/INR) or (EUR)
				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
22.13	Contactors	Nos of each type & rating	5			
22.14	Interposing relay (IPR)	Nos. of each type & rating	10			
22.15	Terminal Blocks	Sets of each type & rating	2			
22.16	Internal wiring control cables	Coil for each type	1			
22.17	Circuit breaker complete set	No. of each type used.	1			
23.0	**LV Switchgear**					
23.1	MCCB with Accessories	Nos of each type & rating	5			
23.2	MPCB with Accessories	Nos of each type & rating	5			
23.3	Overload Relay (OLR)	Nos of each type & rating	5			
23.4	Contactors	Nos of each type & rating	5			
23.5	Current Transformer	Nos of each type & rating	5			
23.6	Voltage Transformer	Nos of each type & rating	3			
23.7	Fuses	Nos of each type & rating	10			
23.8	MCB	Nos of each type & rating	5			

Item No.	Description of Items	Unit	Qty.	Unit Price (BTN/INR) or (EUR) CIP to project site		Total Price (BTN/INR) or (EUR)
				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
23.9	Indication Lamps	Nos of each type & rating	10			
23.10	Protection relay	No of each type & rating	1			
23.11	Meters	No of each type & rating	1			
23.12	Switches	No of each type & rating	5			
23.13	Push button	No of each type & rating	5			
23.14	ACB Close coil	Nos of each type & rating	2			
23.15	ACB Trip coil	Nos of each type & rating	2			
23.16	ACB Spring Charge Motor	Nos of each type & rating	2			
23.17	Fixed and moving contact assemblies of breaker	Sets of each type & rating	2			
23.18	Interposing relay (IPR)	Nos. of each type & rating	10			
23.19	Terminal Blocks	Sets of each type & rating	2			
23.20	Internal wiring control cables	Coil for each type	1			
24.0	**AUXILIARY TRANSFORMERS**					
24.1	**MV Station Auxiliary Transformers (33/11kv)**					

Item No.	Description of Items	Unit	Qty.	Unit Price (BTN/INR) or (EUR) CIP to project site		Total Price (BTN/INR) or (EUR)
				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
i)	HV Bushing	Nos. of each type & rating	3			
ii)	LV Bushing	Nos. of each type & rating	3			
iii)	Neutral bushing	Nos. of each type & rating	3			
iv)	Buchholz relay complete (main tank)	No. of each type & rating	1			
v)	Local Winding temperature indicator	No. of each type & rating	1			
vi)	Remote winding temperature indicator with sensing device and matching unit	No. of each type & rating	1			
vii)	Oil temperature indicator	No. of each type & rating	1			
viii)	Pressure relief device	No. of each type & rating	1			
ix)	Magnetic oil level gauge	No. of each type & rating	1			
x)	Cooler Fan with motor	No. of each type & rating	1			
xi)	Set of Valves	No. of each size and type	1			
xii)	Set of starters, contactors, relays and switches for electrical control panel	No. of each type & rating	1			
xiii)	Remote tap position indicator	No. of each type & rating	1			
xiv)	Oil flow indicator	Set of each type & rating	1			

Item No.	Description of Items	Unit	Qty.	Unit Price (BTN/INR) or (EUR) CIP to project site		Total Price (BTN/INR) or (EUR)
				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
xv)	Terminal connector	Set of each type & rating	1			
xvi)	Gaskets for Bushings, flanges, manholes	Set of each type & rating	1			
xvii)	Insulating oil	Quantity of oil	10%			
24.2	**LT Transformers & Accessories, Unit Aux Transformer 13.8/0.433 kV**					
i)	HV Bushing / Insulator	Sets of each type and rating	2			
ii)	LV Bushing / Insulator	Sets of each type and rating	2			
iii)	WTI with sensing device	Sets	2			
iv)	OTI with sensing device (if applicable)	Sets	2			
v)	Tap Changer contacts	Sets	2			
vi)	Door switch	Sets	2			
vii)	Current transformer used	Sets of each type and rating	2			
viii)	Buchholz relay (if applicable)	No Each type	1			
ix)	Explosion vent diaphragm (if applicable)	No Each type	1			
x)	Silica gel Container (if applicable)	No Each type	1			
24.3	**Station Service Transformer 11/0.433 kV**					

Item No.	Description of Items	Unit	Qty.	Unit Price (BTN/INR) or (EUR) CIP to project site		Total Price (BTN/INR) or (EUR)
				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
i)	HV Bushing / Insulator	Sets of each type and rating	2			
ii)	LV Bushing / Insulator	Sets of each type and rating	2			
iii)	WTI with sensing device	Sets	2			
iv)	OTI with sensing device (if applicable)	Sets	2			
v)	Tap Changer contacts	Sets	2			
vi)	Door switch	Sets	2			
vii)	Current transformer used	Sets of each type and rating	2			
viii)	Buchholz relay (if applicable)	No Each type	1			
ix)	Explosion vent diaphragm (if applicable)	No Each type	1			
x)	Silica gel Container (if applicable)	No Each type	1			
25.0	**Lighting System**					
25.1	Indoor light fixture	Nos. of each type & rating	3			
25.2	Outdoor light fixture	Nos. of each type & rating	3			
25.3	Switches	Nos. of each type & rating	10			

Item No.	Description of Items	Unit	Qty.	Unit Price (BTN/INR) or (EUR) CIP to project site		Total Price (BTN/INR) or (EUR)
				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
25.4	Receptacles	Nos. of each type & rating	10			
25.5	Receptacles (3Ph)	Nos. of each type & rating	2			
25.6	MCCB	Nos. of each type & rating	5			
25.7	RCBO	Nos. of each type & rating	10			
25.8	MCB	Nos. of each type & rating	10			
25.9	Wire coil for lighting system	coil for each type & rating	1			
25.10	Wall mounted lighting pole	Nos.	5			
25.11	Switch box	Nos. of each type	2			
25.12	MCB Box	Nos. of each type	2			
25.13	Lamps	Nos. of each type	50			
25.14	Multi plug					
i)	5A/15A	Nos. of each type used	20			
ii)	6A/32A	Nos. of each type used	10			
iii)	63A	Nos. of each type used	5			
iv)	126A	Nos. of each type used	2			

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				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
26.0	**Earthing & Lightning Protection System**					
26.1	Earth busbar	Nos. of each type & rating	10			
26.2	Connectors, Bolts, Nuts, washers, Lugs, clamps, screws, fasteners, etc.	Sets of each type & rating	10			
26.3	Junction boxes	Nos of each type & rating	10			
26.4	Link Boxes	Nos. of each type & rating	5			
26.5	Earthing rod / pipe with accessories	Nos. of each type & rating	5			
26.6	Lightning rod with mounting accessories	Nos. of each type & rating	5			
27.0	**Emergency Diesel Generator And Accessories**					
27.1	Piston Ring oil ring set – for complete engine	Set of each type & rating	1			
27.2	Cylinder head gaskets – for complete engine	Set of each type & rating	1			
27.3	Fuel injector assembly complete with valve and holder – for complete engine	Set of each type & rating	1			
27.4	Fuel injector valve set – for complete engine	Set of each type & rating	1			
27.5	Compressed air system – service kit	Set of each type & rating	1			
27.6	Inlet/exhaust valves – for complete engine	Set of each type & rating	1			

Item No.	Description of Items	Unit	Qty.	Unit Price (BTN/INR) or (EUR) CIP to project site		Total Price (BTN/INR) or (EUR)
				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
27.7	Packing gaskets, O-rings and seals – for complete engine	Set of each type & rating	1			
27.8	Bearings shells – for complete engine	Set of each type & rating	1			
27.9	Lubricating oil filter	Set of each type & rating	1			
27.10	Instruments, sensors & transducers	Set of each type & rating	1			
27.11	V-belts, timing belts – for complete engine	Set of each type & rating	1			
27.12	Starting/crank assembly (including motor, solenoid, etc.,)	Set of each type & rating	1			
27.13	Fuel shut-off solenoid valve	Set of each type & rating	1			
27.14	Fuel filter element	Set of each type & rating	1			
27.15	Air filter element	Set of each type & rating	1			
27.16	Resistive load bank circuit contactor	Set of each type & rating	1			
27.17	AVR (Auto Voltage Regulator)/ AVR card	Set	1			
27.18	MCB/MCCB	No. of each type	1			
27.19	Governor card	No. of each type	1			
27.20	Contractors	No. of each type	1			

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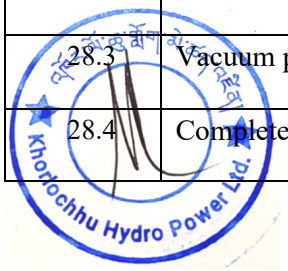
Item No.	Description of Items	Unit	Qty.	Unit Price (BTN/INR) or (EUR) CIP to project site		Total Price (BTN/INR) or (EUR)
				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
27.21	Breaker Control Switch	Nos. of each type	2			
27.22	ON/OFF switch, 2 and 3 way switch, selector switch	Nos. of each type	2			
27.23	Valves	Nos. of each type	2			
27.24	Collector brush holders	Set of each type & rating	1			
27.25	Collector brush sets	Set of each type & rating	1			
27.26	Excitation/AVR system modules & printed circuit cards	Set of each type & rating	1			
27.27	Bearings	Set of each type & rating	1			
27.28	Control panel electrical components	Set of each type & rating	1			
28.0	**Lubrication Oil Handling & Purification System**					
28.1	Connecting hose with couplings of each type and size	Nos. of standard lengths of each type	2			
28.2	Oil pump of all type	No. of each type	1			
28.3	Vacuum pump of all type	No. of each type	1			
28.4	Complete set of seals and gaskets for the system	Set comprising	1			



Item No.	Description of Items	Unit	Qty.	Unit Price (BTN/INR) or (EUR) CIP to project site		Total Price (BTN/INR) or (EUR)
				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
		of each of these items)				
28.5	Complete set of filters for the system	Set comprising of each of these items)	1			
28.6	Complete set of valves for the system	Set comprising of each of these items)	1			
28.7	Instrument (Pressure/ Vacuum gauges, Level indicators)	No. of each type used	1			
28.8	Heating Element	Nos. of each type used	5			
29.0	**Electrical and Mechanical Workshop**					
29.1	Bidder shall proposed required Mandatory Spares	Lot	1			
30.0	**Plant Communication and Public Addressing System**					
31.1	Electronic cards	Set of each type	1			
31.1	Power Supply	No. of each type	1			
31.1	Amplifiers	No. of each type	1			
31.1	Handsets	No. of each type	1			
31.1	Microphone & Loudspeakers	No. of each type	1			

Item No.	Description of Items	Unit	Qty.	Unit Price (BTN/INR) or (EUR) CIP to project site		Total Price (BTN/INR) or (EUR)
				(In figures)	(In Words)	
(1)	(2)	(3)	(4)	(5)	(6)	(7=4x5)
31.1	Set of spares for Radio communication	Set of each type	1			
31.1	Walkie-Talkie	No. of each type	1			
31.1	Cable	Total Qty	10%			
31.1	Connectors	Sets of each type	5			
31.0	**Security and Surveillance System**					
31.1	Electronic cards of each type used in the system	No.	1			
31.2	Camera with zoom lenses and accessories	Nos.	2			
31.3	Cables of all type	M	100			
32.0	**Fibre Optic Communication System**					
32.1	SDH Equipment, Common cards, Cross Connect/control cards, optical base cards, power supply cards	Set	1			
32.2	Optical Interface Cards	Set	1			
32.3	Interface cards & accessories	Set	1			
32.4	Ethernet Interface 10/100 Base T with Layer-2 switching (Min 9 Interfaces per card)	Set	1			
32.5	Gigabit Ethernet (Layer 2) Interface (min. 1 nos.)	Set	1			
32.6	VOIP telephone with 01 common switch (min 9 port)	Set	1			
32.7	Patch cord	Nos each Type	6			



KHORLOCHHU HYDRO POWER LIMITED

4x150 MW KHORLOCHHU HYDROPOWER PROJECT

TRASHIYANGTSE; BHUTAN

BIDDING DOCUMENT

FOR

CONTRACT PACKAGE: KEM-1

DESIGN, MANUFACTURING, SUPPLY, INSTALLATION, TESTING AND COMMISSIONING OF ELECTRO-MECHANICAL WORKS

VOLUME - 4

EMPLOYER'S REQUIREMENTS

GENERAL TECHNICAL SPECIFICATIONS (GTS)

International Competitive Bidding

These documents are meant for the exclusive purpose of bidding against this NIT and shall not be transferred, reproduced or otherwise used for purposes other than that for which they are specifically issued.

Tender Ref. No. KHPL/C&PD/TENDER:KEM-1/2025/11534 dt. 07.08.2025

LAYOUT OF BIDDING DOCUMENTS

CONTRACT PACKAGE: KEM - 1

Design, Manufacturing, Supply, Installation, Testing and Commissioning of Electro-Mechanical Works

Volume - 1: Instructions to Bidders (ITB)

- Section - 1 Abridged Notice Inviting Tender and Notice Inviting Tender (NIT)
- Section - 2 Instructions to Bidders (ITB), Bid Data, Qualification Forms, Information for Bidders (IFB) and Work Schedule

Volume - 2: General Conditions of Contract (GCC) and Particular Conditions of Contract (PCC)

- Section - 3 FIDIC General Conditions of Contract (GCC) for Plant and Design-Build Contract (First Edition 1999)
- Section - 4 Particular Conditions of Contract (PCC) and Appendix to Tender
- Section - 5 Forms and Procedures

  Form-1: Letter of Tender
  Form-2: Form of Contract Agreement
  Form-3: Bank Guarantee Form for Performance Security
  Form-4: Bank Guarantee Form for Advance Payment
  Form-5: Form of Taking Over Certificate
  Form-6: Bank Guarantee Form for Release of Retention Money
  Form-7: Hindrance Register
  Form-8: Dispute Adjudication Agreement
  Form-9: Parent/Holding Company Agreement
  Form-10: Proforma for Joint Deed of Undertaking

Volume-3: Price Schedules

Volume-4: Employer's Requirements

- Section - 6 General Technical Specifications (GTS)
- Section - 7 Particular Technical Specifications (PTS)
- Section - 8 Quality Assurance Plan (QAP)

Volume-5: Tender Drawings

Volume-6: Technical Data Sheets



SECTION – 6
GENERAL TECHNICAL SPECIFICATION
(GTS)



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SECTION-6: GENERAL TECHNICAL SPECIFICATIONS

1 General Requirements

1.1 General

The Bidder shall strictly observe this General Technical Specification in conjunction with the Particular Technical Specifications. He shall carry out all work in a skilled and workmen like manner incompliance with modern methods of engineering. All design, calculations, materials, works, manufacturing and testing shall conform to the latest applicable standards.

Wherever a Bidder deviates from these specifications, he shall furnish the data called for in the Technical Data Schedules and give a summary of and the reasons for all deviations in the "Schedule of Deviations" as per Volume-6: Data Sheets. Failure to accomplish this may cause the elimination of his tender, especially when a major deviation is involved.

In addition, Bidder shall confirm to all applicable regulations regarding the execution of construction and installation work and shall follow all instructions issued by the Employer.

The particular technical specifications shall take precedence over the general technical specifications in case of any contradiction. Clause number cross-references refer to the volume in which they occur unless stated otherwise.

1.1.1 Brief Description of the Project

Khorlochhu H.P. Project, located in the District Trashiyangtse of Bhutan, is a run of the river scheme with small storage capacity for power generation. The installed capacity of Khorlochhu H.P. Project has been proposed as 600 MW comprising of four units of 150 MW each driven by Vertical Pelton Turbine operating under design head of 761.5 m.

The electro-mechanical equipment would be installed in an Underground Powerhouse. There will be two caverns i.e. Main Powerhouse cavern and Transformer cavern. Main Inlet Valves, Turbines, Generators and Auxiliary equipment would be housed in the Main Powerhouse cavern. The Generator Step up Transformers, Shunt Reactor, TRT gates and GIS would be accommodated in the Transformer cavern. The 420 kV Gas Insulated Switchgear (GIS) would be installed in the Transformer cavern on the floor above the Generator Step up Transformers. Isolated Phase Bus Ducts (IPBD) connecting the Generator Transformer with the Generator will be routed through the interconnecting tunnels between the two caverns. LAVTs, UATs, Excitation Transformers and Dynamic Braking panels will also be housed in the interconnecting tunnel. The terminal equipment for the proposed 2 numbers of 400kV outgoing lines and 1 number Interconnecting Transformer (ICT) will be installed in the Pothead Yard. The connection between equipment located at Pothead Yard and respective GIS bays located in the Transformer cavern would be made through 400kV XLPE cables as indicated in the Single Line Diagram drawing. The layout of equipment are indicated in the relevant layout drawings enclosed in Volume-5 of Bid Document.

1.1.2 Main Project Features

The project shall comprise of following major components:

i) A 95 m high concrete gravity dam with its 5 spillway radial gates,

Khorlochhu Hydro Power Ltd.

ii) Water conductor system comprising of 2 No. gated intake structures with inclined trash rack and with 2 No. de-silting chambers and 1 no. 16.30Km long 5.7 meter diameter horse shoe Shape head race tunnel,

iii) One no. surge shaft leading to two steel lined pressure shafts of 3.3 m diameter. Each bifurcating into two limbs of 2.35 m dia to feed four units in the powerhouse,

iv) Two nos. butterfly valve house chamber near surge shaft,

v) Four units of 150 MW each at Generator terminal at rated condition,

vi) An underground Powerhouse housing four (4) MIVs of spherical type, vertical shaft generating units, each composed of a Pelton turbine directly coupled to a synchronous generator and other related auxiliaries,

vii) A Transformer cum GIS cavern having 13 nos. 13.8 / 400/√3kVsingle phase generator transformers, 82 MVAR bus reactors and 420kV GIS,

viii) A 400 kV pothead yard area at surface for evacuation of generated power through 400kV transmission lines.

1.1.3 Implementation of the Project

Khorlochhu Hydro Power Project is being executed by Khorlochhu Hydro Power Limited (KHPL) of Kingdom of Bhutan.

1.1.4 Salient Features

Some of the features of the project are described below:

Sl. No.	Description	Particulars
1	FRL	EL1572.0 M
2	MDDL	EL1558.0 M
3	Centre Line of the Turbine	EL 772.5 M
4	Gross storage at FRL	2.9 MCM
5	Design Head	761.5M (net)
6	Turbine Type	Pelton
7	Installed Capacity	600 MW
8	No. and size of Units	4 units of 150 MW each
9	Generation voltage	13.8kV
10	Transmission voltage	400kV
11	Type of Powerhouse	Underground
12	Type of Switchyard	Gas Insulated Switchgear System
13	GSU Transformer	63 MVA, Single Phase, 50 Hz, 13.8 / 400/√3kV OFWF type
14	Method of connection between GSU transformer and GIS	420kV Gas Insulated Bus Duct (GIB)
15	Method of connection between Pot yard and GIS	400kV XLPE Cable

1.2 Operating Requirement

1.2.1 General

The Bidder shall strictly observe this General Technical Specification in conjunction with the Particular Technical Specifications. He shall carry out all work in a skilled and good workmanship in compliance with modern methods of engineering. All design, calculations, materials, works, manufacturing and testing shall conform to the latest applicable standards.

Wherever a Bidder deviates from these specifications, he shall furnish the data called for in the technical Data Schedules and give a summary of and the reasons for all deviations in the "List of Deviations" as per Volume-6. Failure to accomplish this may cause the elimination of his tender, especially when a major deviation is involved.

In addition, the Bidder shall confirm to all applicable regulations regarding the execution of construction and installation work and shall follow all instructions issued by the Employer/KHPL.

The particular technical specifications shall take precedence over the general technical specifications in case of any contradiction. Clause number cross-references refer to the volume in which they occur unless stated otherwise.

The equipment/ system to be supplied under this contract shall be suitable for continuous operation under varying grid parameters as allowed in latest "Indian Electricity Grid Code" and "Indian Electricity Rule" OR Latest "Bhutan Grid Code" whichever is stringent.

The equipment/ system shall be designed to operate continuously without any problem under ± 10 % voltage variation and ± 5% frequency variation. Temperature rise/ variation limit for equipment shall be determined considering the above variation. Frequent start/ stop requirement of all equipment for daily operation shall be taken into consideration while designing.

1.2.2 Special Requirement

The Contractor shall submit a detailed work program to the Engineer within 49 days from the issuance of Letter of Acceptance made in the form of critical path method (CPM), the Program Evaluation and Review Technique (PERT) network, using a latest project management software Primavera and showing the sequence in which it proposes to design, manufacture, transport, assemble, install and Pre-commission the Facilities. The schedule shall identify the critical path activities and shall have capabilities of predicting completion date of the Works with periodic progress updates during the execution of contract. The work program shall be prepared after taking into account the requirement of schedule of activities to be undertaken/or completed by Civil Bidders of the Project as per Bar Chart/ PERT Chart attached in Section-2 of Volume-1. Bidder shall take into account all the financial implications for the same and indicate in the pricing proposal.

1.2.3 Auxiliary Voltages

The electrical equipment like switchboards, MCCB, Surge Protection Devices, motors, contactors, relays, luminaries, heaters, switches, sockets, Terminal Blocks, Power outlets etc. should be rated for any of the following voltages:

i) **AC Power**

Three-phase system with grounded neutral for feeding three-phase and single-phase equipment (connected between phase and neutral), type TN-C 415/240V ± 10% and 50Hz ± 5%. All motors and other electrical apparatus should be designed to work continuously under ±5% frequency variation and ±10% voltage variation.

ii) **DC Power**

a) 220V ± (Plus / minus) 10% DC Systems, ungrounded, with earth fault detection for the supply to main control circuits for high and medium voltage switchgear, protection circuits and to other larger essentials loads,

b) Other voltage systems eventually needed, shall be generated from the above systems by means of dc/dc converters, inverters etc.

1.3 Packaging of Electro-Mechanical Works

i) The complete Electro-Mechanical works has been clustered into sub-Packages described as below:

a) **Package KEM - 1**

The package-1 shall comprise of complete works as detailed in respective sections of the specification in respect of Turbine & Accessories, Generator & Accessories, Main Inlet Valves, Electric Overhead Traveling Cranes, Butterfly Valves, Oil Handling & Purification System, Cooling Water System, Isolated Phase Bus Duct, Grounding & Lighting Protection System, Drainage & Dewatering System, and Compressed Air System. Generator Transformers & Auxiliary Transformers, Inter-connecting Transformers, Shunt Reactor, MV Switchgears, LV Switchgears, 400kV & 132 kV Pothead Yard Equipment, Cable Trays & Racks. 420 kV Gas Insulated Switchgear and Associated equipment. 400/132 kV XLPE Insulated Power Cables, Accessories and Cables Support System, Air Conditioning & Ventilation System, Firefighting & Fire Protection System, Public Address & Communication System, Security & Surveillance System, Illumination System, Electrical Testing Laboratory and Mechanical Workshop.

b) **Package KEM - 2**

The package-2 shall comprise of complete works as detailed in the specification in respect of (B) Digital Governing System with Valve table assembly (VTA), Excitation System (Excluding Excitation Transformer and Dynamic Braking Isolator), Unit Control System, Common Control System, Switchgear Control Board (SCB), Dam Control Board, HT/LT and 220VDC Control Boards, BVC and Chalangchhu Intake Control Board, TRT Control Panel, Metering Panel, SCADA System and Protection System.

ii) This document pertains to both the Contract Packages (KEM – 1&2) as indicated above and there may be some item (s) /clause (s) which may not be relevant to this package.

iii) The Bidder shall ensure the functional and physical compatibility of supply at each physical interface among his sub bidders, civil contractors as well as Suppliers of other E&M packages in order to ensure efficient, reliable and safe operation of the whole system/ Scheme. The Bidder shall also resolve all interfacing requirements among various other contractors for execution of the work as per scope of contract.

1.4 Scope of Work

The scope of work comprises the Design, Engineering, Manufacture, Inspection & Testing at Manufacturer's works, Supply, Transport, Insurance, loading/unloading, Storage (including development of storage area and facilities), Erection, Testing, Commissioning, Field Acceptance Test, Quality Assurance and training of purchaser's personnel for the following electro-mechanical equipment as detailed in the Particular Technical Specifications.

i) Turbine and Accessories,
ii) Digital Governing System,

iii) Generator and Accessories,
iv) Excitation System,
v) Unit Control System,
vi) Main Inlet Valve (MIV),
vii) Electric Overhead Traveling (EOT) Crane,
viii) Butterfly Valve (BFV),
ix) Lubrication Oil Handling and Purification System,
x) Cooling Water System,
xi) Isolated Phase Bus Duct (IPBD),
xii) Grounding and Lighting Protection System,
xiii) Drainage & Dewatering System,
xiv) Compressed Air System.
xv) Protection System
xvi) SCADA

These works include coordination and preparation of the detailed drawings in cooperation with the concerned civil contractors, erection and installation drawings as well as calculations, material specifications, operation and maintenance instructions, etc., as detailed in the technical specifications.

The contractor shall design, manufacture, transport, erect, install, test and commission the above electro-mechanical equipment in every respect with all necessary accessories for reliable continuous operation. This shall be done in accordance with the contractor's standard procedures.

These specifications include the performance of all works and the provision of all materials, permanent and temporary equipment, tools, accessories for transport to the installation sites including loading, unloading, if necessary, reloading, intermediate storages, protection and guarding of the equipment, cleaning, drying, complete installation, painting, testing and commissioning of all equipment and accessories.

The contractor shall nominate a project manager who will act as in-charge for the purpose of the project.

The contractor shall provide unskilled and skilled manpower including supervisors and engineers for carrying out services under the contract. The contractor shall also make competent and experienced staff available for the training and assistance of the operating staff during commissioning and trial operation and, if required by the employer, for a period after completion of the trial operation which shall be agreed separately.

Any other items not specifically mentioned above but included in various Chapters of the Bid Document shall be taken into accounts for satisfactory, efficient and reliable operation of the plant.

1.5 Broad Scope

The broad scope of work shall comprise of design, manufacture, inspection and testing at manufacturer's works, packing and forwarding, delivery to site, unloading from carriers/wagons, storing at site, transport to erection site, erection, testing and commissioning at site, carrying out performance / acceptance test, comprehensive insurance till the unit is handed over after commissioning of the following equipment / systems for 4 x 150 MW units.

Sl. No.	Description	Unit	Qty.
1	375 rpm Vertical axis Pelton Turbines with rated output of 152.3 MW + 10% continuous overload capacity at design head of 761.53 m with nozzle opening not more than 85% complete in all respects	Sets	4
2	Digital Governing System and Accessories	Sets	4
3	Main Inlet valve (Spherical type of 1.7 m Diameter) with Upstream Pipe, Bypass arrangement & D/s Dismantling joint and accessories	Sets	4
4	3.3 m Diameter Butterfly valve with upstream pipe, Bypass arrangement & D/s Dismantling joint (BFV Chamber) and Oil pumping unit with accessories complete with oil piping	Sets	2
5	Generator and complete auxiliaries including Local and Remote-control panels, all auxiliary drive motors, local push button stations, etc.	Sets	4
6	Excitation System	Sets	4
7	Instrumentation for Turbine - Generator and Auxiliaries	Sets	4
8	Isolated Phase Busduct (IPBD) & accessories along with neutral grounding transformer & resistor, LAVT cubicles, dynamic braking switch, for each unit.	Sets	4
9	Generator Step Up Transformer (GSUT)-63 MVA, 13.8/400kV, 1-Ph for power evacuation/drawl along with all necessary equipment & accessories, etc.	Sets	12 sets + 1 spare
10	3-phase, 80 MVAr Shunt reactor for 400 kV system	No.	1
11	Interconnecting Transformer (ICT)-67 MVA, 132/400kV, 1-Ph, with Nitrogen Injection Fire protection system (NIFPS) for power evacuation/drawl along with all necessary equipment & accessories, etc.	Sets	3 sets + 1 spare
12	400 kV GIS substation for power evacuation/drawl along with all necessary equipment & accessories, etc. (GT bay-4 Nos, ICT bay-1 No, Line Bay-2 Nos, Bus coupler-1 No, Bus PT-2 Nos, Shunt Reactor Bay-1 No, GIS Local Control Board (LCC) for all Bays, and recommended accessories. Double bus arrangement)	Lot	1
13	420kV & 145kV XLPE Cables	Lot	1
14	400 kV Pothead Yard along with all necessary equipment & accessories, etc.	Lot	1
15	Cooling Water System	Sets	4
16	LP Compressed Air System	Lot	1
17	Drainage & Dewatering System	Lot	1
18	220VDC system complete with battery, chargers and distribution boards for the Power plant as well as GIS.	Lot	1
19	230 VAC UPS for the Power plant as well as GIS.	Lot	1
20	HVAC System	Lot	1
21	Cables and Cabling System	Lot	1
22	Double Girder Electrical Overhead Travelling (EOT) Crane (2 Cranes in Tandem Operation) for Erection Bay including Equalizing beam.	Set	1
23	Electrical Overhead Travelling (EOT) Crane for GIS Building	Set	1

Sl. No.	Description	Unit	Qty.
24	Electrical Overhead Travelling (EOT) crane for BFV Chamber	Set	1
25	Under-slung crane for Workshop Building	Set	1
26	Electric Hoist for Turbine Pit, HVAC room & Drainage pit.	Sets	3
27	Fire Fighting System	Lot	1
28	Fire detection and protection system	Lot	1
29	MV/LV Indoor Switchgears with Segregated / Non-Segregated phase busduct (SPBD/NAPBD) and distribution boards for complete plant	Lot	1
30	Station Auxiliary Transformers (MV) - 3.15 MVA, 33/11kV, 3-Ph, along with all necessary equipment & accessories, etc.	Sets	2
31	LT Service Transformer (Dry Type), 500 KVA, 3-Ph 33 kV / 0.433kV along with all necessary equipment & accessories, etc.	Nos.	4
32	LT Service Transformer (Dry Type), 200 KVA, 3-Ph, 33 kV / 0.433kV - along with all necessary equipment & accessories, etc.	Nos.	2
33	LT Service Transformer (Dry Type), 315 KVA, 3-Ph, 11 kV / 0.433kV) - along with all necessary equipment & accessories, etc.	Nos.	3
34	Unit Auxiliary Transformers-2 MVA, 13.8/0.433kV, 3-Ph, along with all necessary equipment & accessories, etc.	Sets	4
35	Station Service Transformers (LV) - 2.5 MVA, 11/0.433kV, 3-Ph, along with all necessary equipment & accessories, etc.	Sets	2
36	Excitation Transformers and Brake Transformers along with all necessary equipment & accessories, etc.	Sets	4
37	Plant Indoor and Outdoor lighting (illumination) system for entire Power plant	Lot	1
38	Grounding mat, Earthing and Lightning protection system for entire Power plant.	Lot	1
39	Diesel Generator sets with, AMF facility. DG set shall be suitable for Black Start function. 11kV, 1250kVA DG Set, (1 No Main and 1 Backup DG Set).	Sets	2
40	Diesel Generator sets with & AMF facility: 415V, 315kVA DG Set	Set	1
41	Diesel Generator sets with & AMF facility: 415V, 125kVA DG Set	Sets	2
42	Lubrication Oil Handling and Purification System	Lot	1
43	Electrical and Mechanical Workshop Equipment	Lot	1
44	Plant Communication system (PCS) & Public Addressing (PA) system	Lot	1
45	Security and Surveillance System	Lot	1
46	Fiber optical terminal equipment (FOTE) / Optical Line Terminal Equipment (OLTE) for Plant end & Grid station end.	Lot	1
47	132 kV Switchyard Bay for ICT connection along with all necessary equipment & accessories, etc. at existing 132kV Korlung Substation.	Lot	1
48	Complete instrumentations with required redundancies and system required for fully automated and remotely operated plant. Systems not in bidders' scope will be interfaced with Plant Control System.	Lot	1

Sl. No.	Description	Unit	Qty.
49	MV & LV power, control and instrumentation cables and cable carrier system for entire power plant.	Lot	1
50	3D modelling and development of integrated model	Lot	1
51	DAM and Surge Shaft Instrumentations	Lot	1
52	HAZOP / HAZID Study	Lot	1

1.6 LOTO (Lockout/Tagout)

As part of this contract, the bidder shall be responsible for the **design, supply and installation** of a comprehensive **Lockout/Tagout (LOTO) system**. This system shall comply with all relevant national and international safety standards.

1.6.1 System Requirements:

The LOTO system shall include, but not be limited to, the following:

i) Electrical lockout devices (for circuit breakers, MCCBs, isolators, switchgear, etc.)
ii) Mechanical lockout devices (for hydraulic control panels, valves, actuators, etc.)
iii) Group lockout boxes, lockout hasps, padlocks
iv) Danger/Warning tags and signage as per IEC/IS standards
v) Central storage cabinets/racks for LOTO devices.

1.7 Selection of Sub-Vendors

Manufacturers/Sub-bidders of major items shall be strictly as per Form-1: Letter of Tender, Attachment No-9 (i) & (ii) enclosed in Volume-2. Generally, no change in manufacturer for supply of such major items shall be allowed. However, in case if it becomes absolutely necessary to change these during the execution of contract due to unforeseen reason, it should be after proper evaluation of new manufacturers/bidders based on their capabilities and resources and approval of the same by Employer.

1.8 Co-ordination and Interfacing

The Bidder shall ensure the functional and physical compatibility of supply at each physical interface among his sub bidders, Civil Contactors as well as Suppliers of other E&M packages in order to ensure efficient, reliable and safe operation of the whole system/Scheme. The information regarding the items to be manufactured/supplied by the sub-supplier and list of such sub-supplier to be provided as per relevant Schedule.

The limits of the supply and the definition of interface indicated by any Sub-bidders/Manufacturers/Vendors shall in no way relieve the Bidder from his obligation to fulfill the scope defined in specifications. The Bidder shall ensure co-ordination among various sub-bidders as well as Civil Bidders and Suppliers of other E&M packages, to verify the continuity and the coherence between themselves. The Bidder shall also resolve all interfacing requirements among various sub-bidders for execution of the work as per scope of contract. Engineer shall provide necessary help for such co-ordinations with different sub bidders (if chosen by Employer).

The Bidder of each Package shall be fully responsible for following Co-ordination works in addition to the normal works as stipulated under this Contract:

i) **Overall Layout Engineering**

Overall layout engineering of the entire E&M works shall be finalized by Package KEM-1 bidder. Other contractors shall provide necessary inputs to prepare the same.

ii) **Functional & Physical compatibility**

The Bidder shall ensure the functional and physical compatibility of supply at each physical interface among his sub bidders, Civil Contactors as well as Suppliers of other E&M packages in order to ensure efficient, reliable and safe operation of the whole system/ Scheme. The information regarding the items to be manufactured/supplied by the sub-supplier and list of such sub-supplier to be provided as per relevant Schedule.

The limits of the supply and the definition of interface indicated by any Sub-bidders/Manufacturers/ Vendors shall in no way relieve the Bidder from his obligation to fulfill the scope defined in specifications.

The Bidder shall ensure co-ordination among various sub-bidders as well as Civil Bidders and Suppliers of other E&M packages, to verify the continuity and the coherence between themselves. The Bidder shall also resolve all interfacing requirements among various sub-bidders for execution of the work as per scope of contract. Engineer/Consultant shall provide necessary help for such co-ordinations with different sub bidders (if chosen by Employer).

iii) **Grounding System**

Design & engineering, supervision, testing and commissioning of complete earthing system for powerhouse complex comprising machine hall & transformer/GIS hall caverns, main access tunnel, cable tunnel, tail race tunnel, outdoor 400kV pot-head yard, BFV chamber etc. shall be in the scope of KEM-1 package.

The Bidder of KEM-1 package shall also include the scope of design, engineering, supply, installation, testing and commissioning of complete lighting protection system for pothead yard, dam, desilting chambers, Chaplangchhu diversion scheme, surge shaft, and TRT outfall including chemical earthing sets and necessary hardware.

iv) **Cables & Cabling Works**

All the Power, Control & Instrumentation cables and cabling works (except cable racks and cable trays) shall be in the scope of Bidder of individual Package. This would include:

All cables and cabling works from individual equipment supplied under each Package up to LCC/marshalling kiosk etc. or any other panel/equipment supplied under same package shall be in the scope of respective packages.

v) **Cable Schedule**

The Bidders shall prepare their own cable schedule and supply for interconnection of their respective equipment to LCC/Marshalling kiosk etc. in view of the cable schedule of entire E&M works for successful commissioning of plant as a whole with proper co-ordination and inputs/data/details/drawings etc. from Bidder of other Packages, whatever the case may be. Further, he shall also indicate properly the terminals for termination of cables (if any) by Bidder of other Packages.

vi) **Commissioning**

Commissioning of the plant as a whole, after successful testing & commissioning of individual item(s)/equipment(s) isolation, along with implementation/interfacing of Control/Protection scheme as per the inputs/data/details/drawings etc. from Bidders of respective packages.

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1.9 Standards

Although European or IEC standards for design, testing, workmanship, material and Works have been mostly selected in these specifications as a basis of reference, other standards and recommendations of standard international organizations will be acceptable provided they ensure equal or higher quality than those specified, and provided, furthermore, that the Bidder submits for approval, detailed standards which he proposes to use. When IEC or ISO Recommendations or other Standards are referred to, the Edition shall be that current at the time of issue of Tender Documents, together with any Amendments issued to that date.

If requested by the Employer, the Bidder shall supply at his own expense three copies in English and one in the original language of any national standards, which are applicable to the Contract.

Standard publications issued by the following organizations of standardization are considered being approved standards for the works:

1.9.1 Standards for General Application

ACI	American Concrete Institute
AGMA	American Gear Manufacturers Association
AISC	American Institute of Steel Construction
AISE	Association of Iron and Steel Engineers
AISI	American Iron and Steel Institute
ANSI	American National Standards Institute
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
ASME	American Society of Mechanical Engineers
AWS	American Welding Society
AWWA	American Water Works Association
BIS	Bureau of Indian Standards
BSI	British Standards Institution
CEMA	Canadian Electrical Manufacturers Association
CMAA	Crane Manufacturers Association of America
CSA	Canadian Standards Association
DIN	Deutsches Institut fur Normung
EN	European Standards
IEC	International Electro-technical Commission
IEEE	Institute of Electrical and Electronics Engineers
IIW	International Institute of Welding
IPCEA	Insulated Power Cable Engineers Association
ISA	Instrument Society of America (Now International society for Automation)
ISO	International Organization for Standardization
JEC	Standards of the Japanese Electro-technical Committee
JIS	Japan Industrial Standards
NEC	National Electrical Code of the U.S.A.
NEMA	National Electrical Manufacturers Association (U.S.A.)
NESC	National Electrical Safety Code of U.S.A.

NFPA	National Fire Protection Association
SA	Society of Automotive Engineers
SSPC	Steel Structure Painting Council (Now Society for Protective Coating)
TEMA	Tubular Exchangers Manufacturers Association
IS	Indian Standard

Notwithstanding reference made to various standards all equipment and works as per provisions and requirements of relevant and latest Indian Standards shall be acceptable.

Basic Design Standards

Sl. No.	Description	Standard
1	ISO System for limits and fits	ISO/286-1988
2	General Tolerances and deviations Part-I	ISO/1829-1975
3	Permissible machining variations in dimensions without tolerance indication	ISO/2768-1973
4	Screw threads	ISO-68-1998, ISO-262-198, ISO-724-198
	General principle of verification of safety of structures	IEC 2394

Standard test methods and definitions for:

Sl. No.	Description	Standards
1	Mechanical testing for steel products	ASTM-A370-2009
2	Tension testing of metallic materials	ISO/82-1959
3	Standard test method for Notched Bar impact	ASTM-E23-2007
4	Testing of Metallic materials	ISO/83-1976
5	Liquid penetrant inspection	ASTM-E165-2002
6	Standard guide for radiographic testing	ASTM-E94-2004
7	Standard practice for ultrasonic examination of heavy forging	ASTM-A388
8	Standard test method for Guided bend test	ASTM-E190-992 (2008)
9	Ductility of weld welders qualification tests	AWS (American Welding Society) Group B, DIN EN 287
10	Preparation of steel surfaces for painting by sand blasting	SIS 05-5900
11	Designation of degree of rusting of paint surfaces	DIN-53210
12	Certificates of material testing	DIN-50049

Material Standards

Materials shall be new and of first-class quality, suitable for the purpose, free from defects and imperfections, and the classifications and grades in conformance with the latest issue of the respective relevant standard. Material to other standards may be used if approval by the Employer has been obtained. Material specifications, including grade or class data, shall be shown on the appropriate detail drawings submitted for review.

If using stock material not specifically prepared for the works under this Contract, the Bidder shall submit evidence that the material complies with approved standards and

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that the material is adequate for the intended use. The Bidder shall indicate in the Technical Data Schedules, the materials and applicable standards for all major parts of the supply. The materials shall be carefully selected for the intended purpose and due consideration of the site conditions and the tropical environment. Higher-grade material shall be used where ordinary material is insufficient.

Electrical Standards

The following basic standards for electrical works or any other approved standard shall be applied:

i) IS (Indian Standards),
ii) Standards issued by IEC (International Electrotechnical Commission),
iii) IEEE (Institute of Electrical and Electronic Engineers),

For specific standards see the Particular Technical Specifications.

Units of Measurements

The international SI-system of units shall be used for documents, calculations, correspondence, drawings, etc., relevant to the Tender and the subsequent Contract.

1.10 Works Identification System

An approved, uniform Works identification system shall be applied for all mechanical, electrical and Instrumentation and Control (I&C) Works to be agreed upon during detailed design.

1.11 Time Schedule

According to the relevant articles in the General and Particular Conditions of Contract, the progress of the work shall conform to the basic Program of Work on which the Contract is based. The "Program" to be submitted shall include the following information:

i) Design work,
ii) Shop work,
iii) Testing and inspection of works,
iv) Transport to the Site,
v) Storage at site,
vi) Preparations at the Site
vii) Interdependence with work of other Bidders,
viii) Erection and commissioning,
ix) Acceptance testing,
x) Handing over,
xi) Removal of erection equipment and clearing of the Site.

The contractor shall pay particular attention to the dates established for the submission of installation and foundation drawings with loading data, anchoring details, recesses, block-out etc.

1.12 Miscellaneous

i) Sole plates, foundation bolts for all equipment, minor chipping, levelling for Turbine, Generator and all other auxiliaries, provision of anchor fasteners as applicable shall be included in the Bidder's scope.

ii) Initial fill of oil, grease, all lubricants, Top-up after the PG test and before handing over of the plant plus 10% extra quantity for the complete equipment shall be included in Bidder's scope.

1.13 Scope of HAZOP / HAZID Study

i) The primary objective of a Hazard identification (HAZID) study is to relate Internal and External hazards which could impact the arrangement of process units and other adjacent facilities. HAZID study is carried out to identify the potential hazards and to reduce the likelihood and consequences of an incident at site that would have a harmful impact to the personnel, asset(s) and environment so that hazards can be assessed or eliminated at source, if possible, prevented or mitigated otherwise.

ii) Hazard and Operability (HAZOP) study is a detailed process which need to be carried out to identify risk and operability problems. HAZOP deals with identification of potential deviation from design intent, examination of causes and assessment of consequences.

iii) The Bidder shall carry out study of all the major hazards associated under this scope of works to demonstrate that the system and its associated ancillaries shall be satisfactorily controlled. Bidder to also execute a Hazard and Operability Study (HAZOP) of the potentially hazardous process systems in accordance with IEC61882 (Hazard and Operability Studies (HAZOP Studies) Application Guide) and IEC 61882 & appoint the HAZOP leader & recorder.

iv) The HAZOP shall be carried out once the design is nearly firm and documented (i.e. once the P&IDs are finalized along with proper control and operation philosophy). All modes of operation shall be included in the HAZOP study but not limited to start, stop, trips of any plant items, transient operation and normal operation. Based on the results obtained from HAZOP Studies, risk ranking shall be obtained. Then the necessary changes /modifications/additional instruments/corrections to the Bidder's design under this scope of works and its ancillaries shall be undertaken by Bidder at no additional cost to the Owner and without affecting the Take Over Date.

v) HAZID & HAZOP study to be conducted in totality for entire project keeping in view Hydro Mechanical aspects ***including Electrical Power distribution related risk assessment study in their scope of work.***

In short, the main objective of the HAZOP study is:

i) To identify safety related hazards and significant operability problems related to the design and operation of the systems.

ii) To determine the seriousness of the consequences for the identified problems.

iii) To identify existing engineering and procedural safeguards that will reduce the consequences related to the hazards.

iv) To evaluate the adequacy of existing engineering and procedural safeguards.

v) To recommend additional safeguards and improvements as necessary

Mainly the HAZOP study includes the following steps:

i) Select the system/subsystem/equipment then frame the intention of the system.

ii) Identify the parameter (guide word) then indicate the deviation in the parameter.

iii) Based on deviation, predict the cause then examine the consequence and detect the HAZARD.

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iv) Take the action for safeguarding the engineered system or administrative controls designed to prevent the cause or mitigate the consequences of deviations.

v) Repeat procedure for particular parameter (guide word) selected until the risk mitigates.

vi) Identify remaining parameters (guide word) and follow the above procedure.

vii) Once all parameters (guide words) are corrected/finished then mark the system as completed.

Based on the above procedure, the study shall be recorded and completed with corrective actions.

The Bidder shall appoint an independent specialist to undertake the HAZID & HAZOP study. The Owner and Owner's consultant shall be invited to attend all HAZID & HAZOP meetings.

1.14 Scope of 3D modelling, development of integrated model, submission of models for review

i) The Bidder shall design the plant in 3D modelling environment by carrying out complete 3D modelling of the plant and progressively issue the 3D model for owner's approval. The 3D model developed by the Bidder shall be compatible with Navisworks Manage software for owner's review. Bidder shall submit both. DGN and .NWD files to the owner. The Bidder shall use the following sequence for development of the 3D model.

- The Bidder shall develop the basic equipment layout drawings (hydro mechanical and civil) containing only the details of equipment location. The base drawings shall not contain details like location of pipes, supports, cable trays etc. After the basic equipment layout drawings have been approved and finalized, the3D model shall be developed based on the basic drawings containing equipment details, piping details, cable trays etc.
- The 2D drawings shall be derived from the 3D model. The model shall be submitted for owners review and approval progressively. The 2D drawings also shall be submitted for Owner's approval.
- After completion of construction work, 'As Built' 3D model shall be submitted to Owner incorporating the actual changes that were carried out during the construction work at site.

ii) Owner Consultant shall share 3D Model for Powerhouse – Civil Structure. Bidder shall create and integrate 3D Model of EM Package with 3D Model of Powerhouse and submit integrated Model for Owner's review and approval. Bidder shall also update 3D Model based on site changes and shall submit the final 3D Model for Owner's acceptance.

iii) The 3D Model review shall be carried out at site along with O&M team. The suggestions & observations shall be incorporated by Bidder with any cost implication to Owner.

1.15 Transport, Storage area, Fabrication and Scrap yard and Office area and facilities.

Transportation, Unloading and storage including construction of required covered storage, open storage, fabrication and Scrap yard and office space shall be by Bidder.

Owner will provide space as in where basis (as available) to bidder for developing these infrastructure facilities. Required grading, levelling, Dismantling and /or demolition shall be Bidder.

1.16 Statutory Approval

Compliance with all applicable statutory requirements, seeking approvals from statutory/regulatory authorities for the equipment supplied, erected/constructed/ installed by Bidder will be in Bidder's scope. Assistance and necessary support as required by the owner for Power Project related statutory/ regulatory matters shall also be provided by Bidder.

1.17 Working on Wrench System

Bidder to follow the "Wrench System" for submission of documents and inspections/document review. The list of document and drawings (MDL-Master document list) to be submitted by Bidder during detailed engineering stage for owner's review/approval/information shall be mutually decided during Kick off meeting for this contract.

1.18 Submission of Native files and editable version of all drawings, documents & calculations:

All the drawings shall be submitted by Bidder in AutoCAD as well as in PDF format. All the reports shall be submitted by Bidder in PDF format to the owner for review as well as for record. Authorized and licensed version shall be used by the Bidder in case of AUTOCAD, MICROSOFT, and ADOBE All documents and drawings for this project shall be in clear and legible English language. All Native files and editable versions of all analysis, studies, drawings, documents & calculations shall be submitted.

1.19 Codes And Standards

i) All equipment, system and works covered under this specification shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed. All equipment and systems shall confirm to the standards / codes specified in Section – C, Section D and Data sheet – A. In case the Bidder offers equipment / systems conforming to any standards other than those specified in component specifications, the same shall be established to be equivalent or superior to the codes and standards as specified and the Bidder shall furnish copies of standards translated in English while submitting his proposal.

ii) Notwithstanding the recommendations and stipulations of the Codes and Standards mentioned above, the requirement of this specification shall be deemed minimum and shall be complied fully.

iii) In the event of conflict between requirements of any two clauses of the Contract document or requirements of the codes/standards, specified, the more stringent requirement shall be complied by Bidder.

iv) All codes and standards referred to in the specification shall be understood to be the latest version as on the date of offer made by the Bidder unless otherwise indicated.

v) The Bidder shall ensure that instruments and gauges to be used for testing and inspection of critical parameters as identified in the specification have valid calibration and the accuracy can be traced to National standards.

1.20 Terminal Points

1.20.1 Mechanical

i. **Main inlet valve (Spherical Valve for Powerhouse)**

Upstream Side: Upstream inlet pipe of suitable length with the site trimming allowance of 300mm. Terminal point welding between the penstock and upstream pipe shall be carried out by Bidder. Cutting and edge preparation of the inlet pipe, cutting and edge preparation of the penstock pipe, welding of inlet pipe (Reducer) with penstock pipe shall be included in Bidder's scope of work. Terminal point distance shall be 10500mm as per tender drawing (Powerhouse General Arrangement Drawing no. KHPP-ME-6017-GA-60001).

ii. **Butterfly Valve Chamber:**

Upstream inlet pipe of suitable length with the site trimming allowance of 300mm. Terminal point welding between the penstock and upstream pipe shall be carried out by Bidder. Cutting and edge preparation of the inlet pipe, cutting and edge preparation of the penstock pipe, welding of inlet pipe with penstock pipe shall be included in Bidder's scope of work. Terminal point distance shall 2500 mm from valve centreline.

Downstream extension piece suitable length with dismantling joint companion flange at one end and another end suitable for welding to penstock with site trimming allowance of 300mm. Terminal point welding between the penstock and upstream pipe shall be carried out by Bidder. Cutting and edge preparation of the extension pipe, cutting and edge preparation of the penstock pipe, welding of extension pipe with penstock pipe shall be included in Bidder's scope of work. Terminal point distance shall 3000 mm from valve centreline (Layout Arrangement of BFV Chamber Drawing no. KHPP-ME-6017-GA-60003).

1.20.2 Electrical

i) Terminal point at pot head yard Gantry structure for takeoff /connection of transmission line system. Supply of FOTE/ PLCC panel and Integration between powerhouse control system and FOTE/ PLCC panel shall be in the scope of Bidder. (Receiving end FOTE / PLCC will be supplied and installed by Transmission line package contractor).

ii) Incoming power / control at Motor terminals / Local Control Panel for Intake Gates, Tail race Gates & Dam bottom outlet drain valve:

iii) Power supply to Civil & HM contractor for Dam and Tailrace area from Powerhouse 11kV switchgear (Power cable and laying up to required point and further distribution in respective package contractor scope.

1.20.3 Instrumentation

i) Complete Power Plant automation, control & instrumentation system is part of EM Package Vendor- All cables, cable laying and termination up to PLC/SCADA System is in E&M vendor scope.

ii) Intake gates, TRT outfall gates - PLC system by Bidder

iii) Dam and Tailrace instruments and field cabling up to PLC.

1.20.4 Exclusions

The equipment and services to be provided by OTHERS shall be as follows: -

i) All civil works other than exclusively mentioned in scope.

ii) 400 kV Transmission lines.

iii) Civil works of earth pits, Cable trench, Brick masonry for earth pit & Trench works (Excavation & Filling) for Earth grid.

iv) Penstocks.

v) Dam, TRT gates & surge shaft gates.

vi) EOT Long travel Girder (However, rails along with fixing arrangement shall be in vendor scope).

vii) Monorail(s) for underslung cranes & hoist.

viii) OPGW cable of 400 kV Transmission line for FOTE

2 Technical Documents and Drawings

2.1 General

This Chapter specifies the general scope and gives a definition of the documents which, together with those listed in the Particular Specifications, shall be delivered by the Bidder to the Employer within the periods, and in a number and quality as specified in the General and Particular Conditions as indicated in Volume-2 of Bidding Document.

The Employer reserves the right to request the Bidder for additional documents as may be required for proper understanding and definition of constructional, operational, co-ordination or other matters.

All documents shall be submitted in accordance with the agreed program so that any comment and change requested by the Employer can be taken into account before starting of the manufacture in the workshop and/or erection or installation at the Site.

If the Bidder fails to submit such documents, then the later execution of changes requested by the Employer and the resulting additional cost and/or delays shall be the Bidder's responsibility.

The Bidder shall not be absolved of his responsibility and guarantee even after drawings and computations have been approved by the Employer.

On drawings, catalogue sheets or pamphlets of standard Works submitted to the Employer, the applicable types, paragraphs, data, etc. Shall either be marked distinctively or the non-applicable parts shall be crossed out. Documents not marked in such a manner will not be accepted and approved by the Employer.

If required for proper understanding of the documents, additional descriptions/explanations shall be given on these documents or on separate sheets. All symbols, marks, abbreviations, etc., appearing on any document shall clearly be explained by a legend on the same document or on an attached sheet.

Each device appearing on any document (drawing, diagram, list, etc.) shall clearly be designated. The abbreviation mark used for an individual device shall be identical throughout the complete documentation so as to avoid confusion. All documents shall have a uniform title-block and agreed by the Employer. Beginning with the very first submittal to the Employer, the Bidder's drawings shall bear a serial number corresponding to a drawing classification plan to be agreed upon by the Bidder and the Employer. All drawings and documents must be in English language.

2.2 Drawings

2.2.1 Loading Drawings

For all larger piece of Works which, due to their dimensions and/or weight and transport limitations, will require special means for their transportation, the Bidder shall submit binding loading drawings indicating dimensions, weights, etc., of the respective pieces of Works and the necessary trailer for its transportation to the site.

2.2.2 Foundation Drawings

If a piece of work requires its own foundation or needs a special area for installation, the Bidder shall submit drawings indicating all pertinent dimensions, static and dynamic loads, etc. They shall include all essential details required for proper design and construction of the foundations and/or buildings.

In addition, these shall include openings, sleeves, slopes and the arrangement of any supporting structure, i.e. base-frames or other steel constructions for permanent fixing or erection purposes.

If conduits are to be installed in the foundations, the relevant information such as diameter, length, and purpose shall be indicated on the drawings.

2.2.3 General Arrangement Drawings

All arrangement drawings shall be drawn to scale. The General Arrangement Drawings shall show the physical arrangement of Works/equipment/assemblies in relation to each other and to agreed co- ordinates and boundaries.

The Arrangement or Layout Drawings of electrical and instrumentation and control equipment shall indicate the location of all apparatus wherever used, i.e. in or on machines, control boards, switchboards, cubicles, control desks and panels, etc. The apparatus shall be denominated with the same standardized abbreviations as used in all other documents.

2.2.4 Outline Drawings

The Outline Drawing shall show all elements and the main dimensions of individual components where necessary in plan view, cross-section, side and top views. If reasonably possible such dimensions can be shown on Arrangement Drawings.

2.2.5 Civil Work Guide Drawings

Civil work Guide drawings shall be drawn to scale. The drawings shall include all civil interfacing details like dimensional details of all openings, cut-outs, insert plates, foundations, trenches, trench cover, rail embedment and floor loading etc. These drawings shall be complete in all respect for working as a reference for preparation of civil construction drawings. Wherever all such information/details are not possible to be included in the drawing of any area, civil work guide drawing shall include all such references of other drawings.

2.2.6 Design Drawings

The Design Drawings shall include outline drawings, assembly manufacturing drawings of components, erection drawings, piping diagrams and piping arrangement drawings, etc., showing the dimensions including fitting tolerances, surface finish, design and data of all constructions, apparatus and Works to be furnished under this Contract.

The drawings shall - where applicable - substantially conform to the Tender Drawings and shall show:

i) Details of manufacturing of major single work pieces specially manufactured for this Contract,
ii) Assembly of the Works in plan and elevation with main dimensions,
iii) Sub-assembly of the principal components of the Works with overall dimensions, adjustment and clearance tolerances, numbers of corresponding detail drawings,
iv) Sub-assemblies in which the Bidder proposes to ship the Works,
v) All necessary details of the parts connecting to the Works supplied by others,
vi) Location and sizes of auxiliary connections for oil, grease, water, air, electrical power etc.,
vii) Location and size of the instruments and accessories provided,

viii) Methods of lubrication and sealing,

ix) Instructions for heat treatment, pressure tests, surface preparation and anti-corrosive protection,

x) Full details of parts for which adjustment is provided or which are subject to wear,

xi) Method and sequence of installation, field joints, erection and lifting devices, jacks, grout plugs, anchoring details, etc., if not shown on foundation drawings.

2.2.7 Installation Drawings

The construction, mechanical, electrical and I&C Installation Drawings shall provide detailed information on the disposition of the various items of a system.

2.3 Diagrams

For electrical diagrams general reference is made to IEC113-1. Notwithstanding reference made to various standards all equipment and works as per provisions and requirements of relevant and latest Indian Standards shall be acceptable.

2.3.1 Block Diagrams

The Block Diagrams shall be used to show in a simplified manner the main inter-relationships between the elements of a system by means of symbols, block symbols and pictures without necessarily showing all the connections. The symbols used for the individual kinds of components, e.g. servomotors, computing modules, etc., shall clearly be explained on the diagram or on an attached legend.

When recommendable, a Block Text Diagram may be prepared, consisting essentially of explanatory texts enclosed in outlines which are linked by lines showing the functional relationships that exist between the various parts of an installation, Works or circuit.

2.3.2 Logic Diagrams

The Logic or Functional Diagrams shall be used for representation of logic and sequence controls and interlocking by showing only binary logic elements and their effect on the various process equipment, disregarding their electrical Realization. Logic function elements (AND, OR, NOR, NAND, STORAGE, etc.) shall be used for processing and combining binary signals.

2.3.3 Process or P & I Diagrams (P&ID)

The Process or P&I Diagrams shall show the piping including type, dimensions, fittings, flanges, etc., and the flow directions. They shall also show the process data, measuring points, instrumentation, control functions and locations of the plant. All P&I Diagrams shall comply with the requirements of ISO–Standards 3511 (process measurement control functions and instrumentation-symbolic representation).

Control gear diagram of mechanical system shall include instrumentations and their control diagram with logic. Detailed specification of instrumentations, operating philosophy etc. may be furnished.

2.3.4 Schematic/Single-Line Diagrams

This is a simplified diagram of the essential Works and their interconnections. Each circuit shall be represented by a single line only. It shall contain all required technical information of the Works represented.

Single-line diagrams of individual main components and switchboards shall additionally show the control, indicating, measuring, metering, protection, automatic and other auxiliary devices separated for each individual installation site and location as applicable:

Furthermore, the applied recommended setting of adjustable devices (protection and control elements, time relays, etc.) shall be indicated.

2.3.5 Electrical Circuit Diagrams

The Circuit Diagrams shall show the power circuits in all the phases with the main apparatus as well as the pilot circuits (measuring and control circuits). It shall show in full the functioning of part or all installations, Works or circuits with all required technical information.

The control part shall be subdivided into separately drawn "current paths", each showing all its components regardless of their actual physical location. The individual circuits are to be drawn in a straight-line sequence, avoiding line crossings. The current paths (to be designated by numbers) shall be drawn starting from two horizontal lines, which represent the control voltage source. All devices belonging to the Works or forming part of the Works or control devices shall appear between these two lines.

Contact developments of the installed switches, contactors, relays and other apparatus which appear in the diagram shall be shown below the respective contactor coil, indicating by means of numbers and, if not on the same, also the page No., the current path in which the corresponding contact has been used.

Interconnections to other circuit diagrams shall be clearly marked by means of dotted line separations and the corresponding functional designation.

The power circuit portion of the installation shall be drawn at the left side of the drawing.

Circuit diagrams shall also contain all terminals and their correct designations. Terminals grouped together to terminal blocks of switchboards, distributors, etc. shall be shown on the circuit diagrams in one fictitious horizontal line surrounded by demarcation lines. If, for any reason, the current paths of circuit diagrams must be separated, the corresponding counter terminal has to be indicated by all means.

The representation of electrical Works and control circuits shall not be terminated at the limits of the scope of supply but has to be extended beyond this limit by all switchgear, protective, measuring and monitoring equipment required for full comprehension of the whole circuit. All terminals and functions of Works to be supplied by others shall be taken over as well.

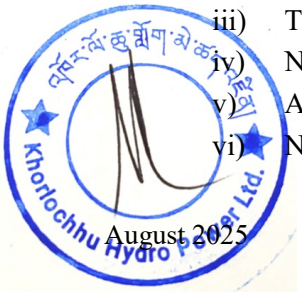
Standard Circuit Diagrams are patterns of circuit diagrams which have been standardized with regard to scope, arrangement, representation and allocation of Works with the aim of simplification and easy surveillance of electrical circuitry.

2.3.6 Terminal Diagrams

Such diagrams shall be prepared for any type of terminal box, marshalling rack, control cubicle, switchboard, etc., and shall show the terminals (properly numbered) and the internal and/or external conductors (wires or cables) connected to them.

The terminal diagram of each individual switchboard, terminal box, panel, etc., shall contain, but not be limited to the following information:

i) Terminal number of terminal board with targets (terminal number and current path) of incoming and outgoing cables and wires,
ii) Cable designation,
iii) Type of cable,
iv) Number and cross-section of conductors,
v) Assignment of conductors,
vi) Number of spare conductors,



vii) Approx. length of cable and its destination.

2.3.7 Protection Co-ordination Diagrams

These diagrams shall show in a graphical manner separately for each power supply circuit:

i) A simplified single-line diagram of the circuit with technical data of all instrument transformers and relays,

ii) Co-ordinated tripping curves of related protection devices,

iii) Setting of the protection devices.

2.3.8 Emergency Shutdown Diagram

This diagram shall show the sequential steps and interdependencies during emergency closure.

2.4 Tender Drawings

Drawings which form part of the bid document have been listed and given in the Bidding Document Volume-5. These drawings depict the basic powerhouse layouts, switching scheme and schematic diagrams of the auxiliary systems viz. the cooling water, compressed air, unit dewatering and station drainage system for the information and reference of the bidders.

The bidder shall verify and submit to the Employer, arrangement and layout, optimized for the actual equipment supplied under this contract, respecting the key dimensions, elevations and concrete outline of the powerhouse that shall remain same as shown in contract drawings.

2.5 Design Memorandum

The Bidder shall prepare and submit to the Employer a "Design Memorandum" of the proposed equipment/system fulfilling the contract specification/requirement given in respective section for approval prior to submission of any drawings and documents. The memorandum shall include the design philosophy, methodology, system description, input parameters for design, standard and codes, design and selection criteria, equipment data, material specification, major technical features, basic arrangement/ layout etc.

Design memorandum of all the equipment/system shall be prepared and first draft shall be submitted within three (3) months from the Commencement Date of Work.

2.6 Drawings & Documents to be supplied by Bidder

2.6.1 Drawings/Documents to be supplied with the Bid

The bidders shall submit the following drawings, technical data/documents/literature & also the drawings as called for in other chapters of this document with their bids:

i) Drawings showing the constructional features & dimensions of various equipment,

ii) Equipment general arrangement drawings showing Plan, Transverse & Longitudinal section, openings in floors for equipment handling, foundation details, embedment etc.,

iii) Performance characteristics of equipment in the form of curves/graphs etc.,

iv) Mechanical control schematic diagram of equipment and Electrical control schematic diagram of equipment,

v) The drawings, data & information shall be elaborate enough to enable the Employer to comprehend and assess the vital details, features, capabilities and functioning of the equipment and their arrangements,

vi) Technical particulars of the equipment and other relevant data,

vii) In addition to drawings, data mentioned in the various technical specifications and technical data sheets,

viii) Type Test Reports.

2.6.2 Drawings/Documents to be supplied after the Award of Contract

The Bidder shall submit to the Engineer the following drawings/documents after the award of contract expeditiously in a sequential manner. The Bidder shall indicate separately the time schedule for submission of drawings for all the equipment covered in different chapters for the approval of Employer, keeping in view the overall commissioning schedule of the project.

i) The Bidder shall prepare and submit to Employer a "Design Memorandum" of the proposed equipment/system fulfilling the contract specification/ requirement for approval prior to submission of drawings and documents in accordance to Clause no.2.5 of this specification,

ii) In addition to the drawings specified in other sections of the document and in Annexure-II of this specification, following drawings & documents shall be submitted.

a) Layout drawings of the power station showing main and auxiliary equipment, switchgear and control gear,

b) Single Line Diagram, Control Schematic drawings for all AC/ DC systems,

c) Key-diagrams, schematic diagrams of all piping systems, controls, protections and alarm system. Wiring diagrams for all electrical circuits cabling layout etc.,

d) Foundations drawings of all components/parts of the plant clearly showing the details of the foundations required for these parts and of all ducts, trenches etc., required for pipes, cables and other accessories. These Drawings shall contain all the information required for designing the civil works,

e) Detailed drawings of the entire equipment which shall include separate drawings of all important components of the plant clearly showing details like mode of fastening etc. The drawings shall be sufficient to furnish a complete understanding of the design and working of the entire equipment and shall contain necessary information required for erection and maintenance,

f) 3-dimensional modeling of the Plant drawing in various areas in the latest Auto desk Inventor Professional software or equivalent. A certified copy of the software shall be supplied for the Employer’s use,

g) Records of all shop testing and inspection of materials, components sub-assemblies, equipment, machinery etc.,

h) Transportation Arrangement drawings for all Consignment,

i) Erection and Installation sequence and procedures,

j) Instructions manuals for operation & maintenance and safety precautions of the plant,

k) Monthly progress reports of equipment manufacture, photographs of equipment under various key stages of manufacture, erection,

l) Any other drawing, literature, documents not specifically listed but considered essential,

m) Quality Assurance Plans indicating the tests to be conducted in Shop and at site.

iii) Bidder shall submit 6 (Six) sets of all drawings and documents along with their soft copy to the Employer for approval/reference. A detail list of drawings to be submitted shall be defined during contract finalization stage.

When drawings are revised, the number of prints of revised drawings, documents to be furnished shall be same as above. The prints shall be clear and legible.

All drawings shall be subject to approval of the Employer and commencement of manufacturing shall not be undertaken prior to such approval. Any modifications/changes in the drawings becoming necessary as a consequence of examination of the drawings by Employer shall be incorporated promptly and revised drawings submitted again to the Employer for formal approval.

The revisions carried out shall be identified on the prints suitably giving serial number of revision, date and details in the revision block. Revised locations in the drawings may be marked by triangles with clearly mentioning the revision number inside the triangle.

It shall be obligatory on the supplier without any additional cost to the Employer to carry out such modifications and changes in the design and drawings which, in the opinion of the Engineer may be necessary to conform the design to the provisions and intent of these specifications.

Approval by the Engineer of the supplier's drawings shall not be held to relieve the supplier of any part of his obligations to meet all requirements of these specifications or of the responsibility for safe and reliable operation of the Plant.

The prints of drawings submitted shall in general be examined and commented upon or approved as the case may be within three weeks of receipt. In case of approvals one (1) print each of drawings shall be marked approved by the Employer and furnished to the supplier.

2.6.3 Final Drawings to be supplied by supplier on Completion of Erection Works

After completion of the erection work the Bidder shall furnish to the Employer six (6) copies including an editable soft copy of final as built drawings of various equipment/systems described in various sections including location/method of fastening of PDA capacitive couplers/electrical connections with PDA analyzer other details as per requirements of various sections of the technical specifications.

2.6.4 Design Calculations

In addition to the drawings or whenever the contractual documents do so require, the Bidder shall submit to the Engineer in-Charge for checking, the appropriate calculations for determining the main sizes, stress levels, dimensions and operational characteristics, safety factors, clearly indicating the principles on which the calculations were based. The calculations shall include the formulae, standards, test results, basic assumptions, etc. Submission of computer calculations without baseline information such as derivation of the calculation method, applied formulas, definition of variables and constants, explanation of abbreviations etc., will not be accepted.

2.7 Specifications

2.7.1 Material Specifications

Such specifications shall be prepared for all principal Works and installations. They shall describe the performance (design, material, dimensions, corrosion protection, etc.) of the Works and include a list of components providing information on the manufacturer, type and technical data to obtain the following:

i) Full information on the Works, completing the general requirements fixed in the Tender Specification by the data/information of the specific manufacture,

ii) Proof of compliance with Contract Specification.

For standard Facilities (for example valves, switchgear, control gear, relays, transmitters, indicators, lighting fittings, etc.) catalogues or pamphlets shall be submitted.

The technical data of electrical Works shall include as a minimum:

i) Max. Permissible ambient conditions (temperatures, humidity),
ii) Rated current and rated output/capacity,
iii) Same data as above under specified severest site conditions,
iv) Rated voltage and ratio or regulation/setting range,
v) Max. Service voltage (acc. to IEC),
vi) Power frequency and impulse withstand voltages,
vii) Type and code No. of protection relays and of instantaneous or thermal releases directly attached to circuit breakers and contactors,
viii) Power requirements for each voltage level (AC/DC).

Specific requirements are described in the following.

a) **Motor Specifications:**

The motor specifications shall include the thermal motor characteristic both for cold and hot condition including sub-zero conditions, the start-up characteristic when running with the driven machine and all data required for selection of the appropriate motor protection relay (both for cold and hot condition) and for locked rotor protection. Construction type, class of protection and insulation shall also be given.

Suitable derating factor as per relevant IS/ IEC shall be applied for altitude above 500m. As per site condition the altitude of installation is EL. 800m and above.

b) **Cable Specifications:**

The General Cable Specification shall include the calculation of the derating factors for the individual modes of installation at applicable ambient temperatures and grouping of cables, and furthermore, for each cross section:

i) The rated current carrying capacity,
ii) The maximum short-circuit capacity,
iii) The voltage drop,
iv) Type, insulation serving, armouring and sheathing of cable,
v) Type, description and catalogue/pamphlet of cable termination.

Separate specification(s) shall be prepared for cable trays, conduits, supporting structures and other accessories.

c) **Measurement and Control Apparatus Specifications:**

The accuracy of performance with respect to variable ambient conditions and the power supply requirements shall be included.

d) **Pumps:**

The pumps shall be suitable for continuous operation. Complete range of operation of pumps with efficiency shall be furnished for each operation. All submersible pumps shall have strainer at their suction side.

The stainless steel shaft shall be finished to close tolerances at the impeller coupling and bearing diameters firmly secured to the shaft with key. The pump impeller and casing shall be of stainless steel and cast steel respectively unless otherwise specified. The pump impeller shall be properly balanced along with any other submachine rotating parts on proper balancing equipment to prevent vibration.

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The base plate accommodating pump and prime mover shall be rigid and stable so that the alignment is not affected even during abnormal operation.

The enclosures shall be water tight, dust-proof and corrosion resistant in accordance with applicable standards/codes in practice.

e) **Pipes:**

Pipes shall be stainless steel pipes as defined in the respective PTS. Pipes shall be provided with sufficient number of flanges in order to facilitate cleaning and inspection.

f) **Valves:**

Valves shall be of gate valves, globe valves, butterfly type etc. as per system requirement. The valve shall be provided with flanges and equipped with removable seal rings of corrosion resistant material.

The valve body and casing shall be of steel, cast steel or of grey cast iron.

The manually operated gate valves shall be equipped with a mechanical blocking device for open and closed positions.

g) **Strainers:**

Strainers shall be made of steel and provided with horizontally flanged inlet and outlet branches. Easy removal of inner parts from above, the filter part shall be made of stainless steel.

The strainers shall be designed for automatic self-back-flushing wherever specified. The supplier shall furnish the specification of strainer such as efficiency, filtering capacity in ppm, discharge capacity etc.

2.8 Lists and Schedules

2.8.1 List of Pipes, Valves, Fittings etc.

This list shall include all the main pipes, valves & fittings etc. required for different purposes covered under this Package and shall contain at least the following information/data.

i) Plant identification number,
ii) Description,
iii) Name of manufacturer & type,
iv) Size & material,
v) Nominal pressure,

2.8.2 List of Pumps, Strainers & Filters etc.

This list shall be prepared according to the requirement of the plant the details of pumps, strainers & filters covered under this contract.

i) Plant identification number,
ii) Description,
iii) Name of the manufacturer & type,
iv) Dimension/weight of complete pump (with motor),
v) Dynamic head,
vi) Speed of pump,
vii) Discharge (m^3 /sec),
viii) Shut off head of pump,
ix) No. of pump impeller/material of impeller.

2.8.3 Motor Lists

The motor lists shall be prepared according to the power distribution boards and schematic diagram of each system. The motors are connected to, and shall contain at least the following information/data:

i) Works identification number,
ii) Description,
iii) Manufacturer, type, rated data of driven machine,
iv) Manufacturer and type of electric motor,
v) Rated capacity,
vi) Service factor (ratio between motor output and power requirement of the driven machine),
vii) Rated speed,
viii) Rated voltage,
ix) Rated current,
x) Ratio of starting current to rated current,
xi) Ratio of pull-out torque to rated torque,
xii) Power factor at rated capacity,
xiii) Efficiency at rated capacity,
xiv) Power consumption at machine design loading,
xv) Total weight,
xvi) Design/enclosure/cooling (acc. to IEC),
xvii) Duty (continuous/intermittent/start-up),
xviii) Starting method/permissible starting frequency,
xix) Denomination of feeder,
xx) Motor Protection and Insulation class,
xxi) Applicable Standard Circuit Diagram (Category),
xxii) Maximum number and overall diameter of power cable(s),
xxiii) Manufacturer and type of bearing(s),
xxiv) Manufacturer, type and quantity of lubricant, service interval,
xxv) Manufacturer, type, number, size, spring pressure and service interval of brushes (if applicable).

2.8.4 Motor Starter Lists

The motor starter lists shall include all starters and contactors used for motors and contain the following technical information as a minimum:

i) Works identification number,
ii) Electrical design data as nominal and actual current rating, voltage rating, coil rating, making and breaking capacity, mode of operation,
iii) Maximum power cable size,
iv) Maximum control cable size,
v) Current transformer ratio, class and capacity,
vi) Type of protection relaying and catalogue number,
vii) Setting of protection relays and maximum continuous rating of the protected circuit,
viii) Type and current rating of the back-up fuses/MCBs for the main and control circuits.

Note:

Motor Starter Lists can be substituted by part lists, already forming part of switchgear manuals.

2.8.5 Cable Lists/Interconnection Lists

The Cable Lists shall include for each individual cable the following as a minimum:

i) Cable number, in accordance with Identification System,
ii) Cable type,
iii) Rated voltage,
iv) Number and size of conductors,
v) Overall diameter,
vi) Cable termination at each end,
vii) Connection point at each end with cubicle/Works identification and terminal numbers,
viii) Cable routing,

In case interconnecting cubicles are used, the lists shall be prepared to show:

ix) Cable termination for incoming and out coming cables,
x) Interconnection wiring,

2.8.6 List of Measurements

This list shall indicate all measurements, local as well as remote, and shall contain at least:

i) Item/code number, function code,
ii) Description and denomination of measuring loop,
iii) Data of tapping point,
iv) Data of local devices (as detectors, instrument transformers, transmitters),
v) Data of remote devices.

2.8.7 Alarm Lists

These lists shall indicate all alarms and shall contain at least:

i) Item/code number and function code,
ii) Description and denomination of alarm,
iii) Data of alarm detector (contact) referring to applicable circuit diagram,
iv) Data of alarm annunciator (location and clear text labeling).

2.8.8 List of Final Control Elements

This list shall indicate all control actuators and control valves and shall contain at least:

i) Item/code number,
ii) Data of pipe and valve connections,
iii) Data of valve layout,
iv) Maximal required and rated power.

2.8.9 Workshop Test Schedules

Individual Workshop Test Schedules shall be prepared including raw material procurement and Works/installations (such as pipes, cranes, machines, switchgears, control gear, cables) and shall contain at least:

i) Works identification number,
ii) Manufacturer,
iii) Place of manufacture,

iv) Place of test,
v) Date of test,
vi) Objective of test (all individual tests),
vii) Standards applied,
viii) Certification,
ix) Inspection (by Engineer/Independent Test Authority/Contractor/Subcontractor),
x) Release for shipment,
xi) Remarks,

On the above schedule or on separate sheets the Test Procedure shall be specified giving for each test item (kind of test) a description, test method/Standards, used instruments, sample/routine test, test judgment.

The raw materials tests for special items such as casting and forging shall be offered for Customer inspection by the contractor. For other raw materials, test certificate shall be furnished for Customer review and acceptance.

2.8.10 Site Test Schedules

Testing at site shall include tests specified in the Model Quality Assurance Plan and any tests recommended by the manufacturers as per their standard practices.

2.8.11 List of Tools and Appliances

Lists of Tools and Appliances shall have detail for all tools and appliances included in the scope of supply:

i) Item and code number,
ii) Description,
iii) Quantity,
iv) Weight,
v) Storage requirements (separate for open-air, indoor, air-conditioned) for individual component sets.

2.8.12 Spare Part Lists

Spare part lists shall detail for all spare parts included in the scope of supply:

i) Detailed drawing (where possible),
ii) Item and code number,
iii) Description,
iv) Quantity,
v) Weight,
vi) Storage requirements (separate for open-air, indoor, air-conditioned) for individual component sets.
vii) Start-up and Mandatory spares

Bidder shall include start-up and essential spares as listed in Section D43.0 of specification. In case any items from these spares are used during installation, commissioning and testing, the Bidder shall replace the same at the time of handing over of the units / completion of facilities.

2.8.13 List of Works Identification Numbers

This list shall contain the used Works identification numbers in alphanumeric order and for each of them a description (the defined Works denomination, for example as written on the Works label) and the location (short definition of outdoor area and level elevation or building/room with elevation and room number).

2.8.14 List of Consumables

This list shall contain details of consumables to be supplied and used in the installation works of Electro-Mechanical equipment. Consumables like, seam, jute, emery paper, welding rods, ferrules, tags, wires, etc. shall be included in the scope of supply for the erection works wherever applicable.

List of Consumables shall include the following:

i) Item and code number,
ii) Description,
iii) Quantity,
iv) Weight,
v) Gross storage requirements (separate for open-air, indoor, air conditioned) for individual component sets.

2.9 Design Calculations

In addition to the drawings or whenever the contractual documents do so require, the Bidder shall submit to the Engineer for checking, the appropriate calculations for determining the main sizes, stress levels, dimensions and operational characteristics, safety factors, clearly indicating the principles on which the calculations were based. The calculations shall include the formulae, standards, test results, basic assumptions, etc. Submission of computer calculations without baseline information such as derivation of the calculation method, applied formulas, definition of variables and constants, explanation of abbreviations etc., will not be accepted. The bidder shall also submit the following design calculation as per specified standard.

i) **Short-Circuit Calculations**

The short-circuit calculations shall be performed in accordance with VDE Standard 0102, part 1/ANSE standard.

ii) **Insulation Co-ordination Study**

The Insulation Co-ordination Study shall be performed in accordance with IEC 60071 and other relevant Indian & International Standards.

2.10 Installation and Commissioning Procedures

2.10.1 Installation Procedures

The installations procedures shall describe in sequential steps for the erection of major equipment and shall contain sufficient details such as equipment preparation on erection bay, handling of large and heavy pieces, levelling, anchoring, site welding, site painting, erection checks, site pressure tests, site flushing and cleaning of hydraulic systems, alignment and run out checks to allow the Engineer/employer to plan and supervise the Works at site, if required. The successful bidder shall furnish a manual of installation procedure, design erection tolerance and list of special tools and equipment for erection.

2.10.2 Pre-Commissioning Tests and Procedures

Pre-commissioning tests and procedures shall be described in sequential steps for the pre-commissioning of all electrical and mechanical equipment and shall also contain sufficient details viz. checking of installations, ratings, cable terminal checking and operation test of all auxiliary equipment etc.

The contractor shall furnish details of safety precautions to be adopted at site during testing. The contractor's skilled workers shall have necessary licenses/certificates to work all electrical and mechanical works. The contractor shall furnish the same to Owner for their review and acceptance.

The contractor shall furnish details of calibration of testing equipment. The testing equipment shall have valid calibration certificates.

2.10.3 Commissioning Procedures

The commissioning procedures shall sequentially and in sufficient detail describe activities and tests for all systems covered by the Contract Document.

2.10.4 Safety

Security checks and surveillance shall be maintained on all areas where work is being carried out and on all areas where plant and equipment is stored, around all living quarters, offices, and stores. Adequate number of lights shall be installed and maintained to provide sufficient illumination at all areas where work is being carried out at night and at all areas where illumination is required for security reasons. Where necessary, an emergency illumination shall be provided with separate electric circuit.

Properly constructed tanks shall be provided by the Contractor for the storage of fuel, oils, and other hazardous material. Such tanks shall be located remote from all work and living places, buildings, storage areas, and vehicle parks.

The Contractor shall take all measures to prevent any fuel or oil or other hazardous or polluting substance entering the river or other water source. All staff and workmen of the Contractor shall be provided with safety helmets, gloves, safety boots, life jackets, and other protective clothing and equipment, as may be required for the work.

The personnel shall be trained in the use of safety equipment and the Contractor shall ensure that such equipment is used in all situations that require it.

Warning signs and notices in Hindi and English shall be provided by the Contractor for all equipment and areas where required by the Engineer I/C for safety purposes and as required by the High Voltage Safety Rules and the Power Station Safety Rules.

All temporary signs necessary for the safety during erection and Tests on Completion of the equipment shall be provided by the Contractor and shall be in Hindi and English.

Safety norms for electrical installation shall be followed as per Indian Electricity Act 2003 and IE Rule 1956 during installation testing and commissioning. Calibration of testing equipment shall be carried out as per relevant IS, IEC and IEEE.

2.10.5 Commissioning Test

Commissioning and acceptance tests shall be carried out, on all generating units to verify the rating characteristics of generating units and other equipment's in accordance to relevant standards. The complete field acceptance test reports shall be prepared by the Bidder and submitted to Employer for approval.

2.10.6 Test Run

The test run on generating units shall be carried out as per relevant provisions of IEC standards.

2.11 Operation and Maintenance Manuals

2.11.1 Contents

The Operation and Maintenance Manuals shall be provided in five (5) hard bound copies along with DVD or any permanent storage device (eight sets), and shall contain the following information in sufficient detail to enable the Employer to maintain, dismantle, reassemble, adjust and operate the Works with all its items of Works and installations:

i) Table of Contents,

ii) List of Illustrations,

iii) Introduction,

The Introduction shall contain:

a) A brief general description of the Works items,
b) A brief description of the use of the Works items,
c) Definitions of technical terms used in subsequent graphs of the instruction book
d) A complete list of all items used in accordance with the Works Components Identification System,

2.11.2 Detailed Description

Detailed description shall contain a complete and accurate description of the Works, all components and ancillaries, their assembling and dismantling. An accurate list stating clearances, tolerances, temperatures, fits, etc. shall be included.

2.11.3 Operating Principles and Characteristics

A brief summary of the technical operating principles of the Works, including diagrams, circuit diagrams, sequence diagrams, piping, etc.

2.11.4 Operating Instructions

The instructions shall be accurate and easy to understand and shall contain the sequence of individual manipulations required for operation. The information shall be presented in such a manner that the contents of this paragraph can be used for instructing personnel in the operation of the Works. Tables, lists and graphic presentations should be used whenever possible for making the description readily understandable. An appropriate trouble-shooting list shall be included in this chapter.

2.11.5 Testing and Adjustment

The entire testing and adjustment procedure required for the Works after overhauls and during operation shall be described.

2.11.6 Maintenance Instructions

This section is divided into six Parts:

i) Preventive maintenance, indicating the inspections required at regular intervals, the inspection procedure, and the routine cleaning and lubricating operations, the regular safety checks and similar steps. The maintenance instructions shall include a tabular (or in other approved form) summary of the required activities sorted according to;

a) Daily,
b) Weekly,
c) Monthly,
d) Quarterly,
e) Yearly,
f) (Or other) cycles as applicable,
g) Standard Operating Procedures for determination of Residual life assessment of all equipment under this contract.

This document shall provide the maintenance engineer with brief and yet fully comprehensive information including all references to the applicable, detailed service and maintenance instructions.

ii) Repair and adjustment, describing the inspections, fitting and dismantling of parts, fault tracing as well as repair and adjustment procedures.

iii) Spare part lists, containing all the necessary data for ordering spare parts. These lists shall include all spare parts, those to be supplied and those not to be supplied

under the present Contract. The prices for spare parts shall be indicated in the list. Detailed drawing for each item of spare parts shall be supplied. The above list should include minimum and maximum quantities of spares to be maintained by the project.

iv) Tool lists, containing all necessary data for identification of tools to be delivered under the present Contract.

v) List of suppliers and alternative suppliers and addresses.

vi) As-built Drawings: As built drawings shall be prepared and submitted for all works, equipment and components incorporating all changes made during execution of works till commissioning. As built drawings shall consist of three hard copies and another six sets in DVD form.

2.11.7 Operation and Maintenance Manual Drawings

Each kind of drawing aforementioned shall have a uniform size. The final size of drawings for the Operation and Maintenance Manual shall be decided by the Employer. Catalogue sheets, illustrations, printed specifications, etc., shall be checked and prepared by the Bidder in such a way that the figures, statements and data valid for the delivered sizes and types of the Works concerned are clearly marked. All figures, statements and data valid for sizes and types not delivered must be crossed out.

2.11.8 Revisions and Supplements

The completeness of the manuals shall be checked during installation, testing, commissioning and trial operation jointly by the Bidder and Employer.

If it becomes evident during the installation, commissioning trial operation and defects liability period of the Works that the Operation and Maintenance Manuals are inadequate or incorrect, the Bidder shall supply immediately the necessary supplements and corrections. This shall be handled in the following manner:

i) **Deletions:**

One sheet of errata, printed on pink paper, shall be issued indicating the pages and date of issue of those pages, which are to be deleted, and are no longer valid.

ii) **Corrections, Revisions, Replacements:**

New sheet (s) shall be issued to replace the wrong pages. Whenever a new sheet is added to the instruction manuals, this sheet shall be given the new date of issue and a revision symbol, and an indication "Substituted for" and a marking of the corrected/revised items.

iii) **Insertions, Supplements:**

Insertions or supplements shall be accompanied by a new respective "Table of Contents" page, where the latter shall be handled as described above under replacements.

The revisions and supplements requested by the Employer shall be made by the Bidder at the Site as far as possible and shall be submitted in each case to the Employer for checking and revision as stated above.

Before issuing the "Taking-Over Certificate", the revised copies of the Operation and Maintenance Manual shall be submitted together with the specified number of complete sets of drawings of the Works as completed. The Works shall not be considered complete for purposes of taking over under the terms of the General Conditions of the Contract until the above documents have been supplied by the Bidder.

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2.12 Progress Reports during Design and Manufacturing

During design and manufacturing the Bidder shall monthly submit four (4) copies of the progress reports in a format acceptable to the Engineer, detailing the progress of the work during the preceding period. The report shall contain but not be limited to the following information:

i) A general description of the Works performed during the reporting period on each main activity, and includes any notable problems, which were encountered,

ii) The total overall percentages of design and manufacturing works completed, with reference to the CPM program. Appropriate comments shall explain any differences,

iii) The percentages of each main work activity completed during the reported quarter with reference versus the scheduled program. Appropriate comments shall explain any differences,

iv) A list of all activities of scheduled and actual progress during the reporting period including actual starting dates versus scheduled starting dates and actual completion dates versus scheduled completion dates for each activity. Appropriate remarks shall explain any differences, and also methods/actions prepared to be taken for making up the deficiencies in actual design and manufacturing process,

v) A list of activities scheduled to be started within the next period of two (2) months, with expected starting and completion dates. If the expected starting and/or completion dates are different from those shown on the CPM program, an explanation shall be given.

2.13 Progress Reports during Installation at Site

During erection the Bidder shall, submit the progress report once in the fifteen days, (Twice in the month), submit four (4) copies of the monthly progress reports in a format acceptable to the Employer, detailing the progress of the work during the preceding month. The report shall contain but not be limited to the following information:

i) A general description of the Works performed during the reporting period on each main activity, and includes any notable problems, which were encountered,

ii) The total overall percentage of erection works completed, with reference to the CPM program. Appropriate comments shall explain any differences,

iii) The percentages of each main work activity completed during the reported month with reference versus the scheduled program. Appropriate comments shall explain any differences,

iv) A list of all activities of scheduled and actual progress during the reporting period including actual starting dates versus scheduled starting dates and actual completion dates versus scheduled completion dates for each activity. Appropriate remarks shall explain any differences,

v) A list of activities scheduled to be started within the next period of two (2) months, with expected starting and completion dates. If the expected starting and/or completion dates are different from those shown on the CPM program, an explanation shall be given,

vi) A list of local manpower (by trade classification) employed during the reporting period,

vii) A list of expatriate personnel (by position) employed during the reporting period,

viii) A list of the Bidder's Equipment and materials presently located at the Site. Also a list of equipment and materials, which arrived at Port of entry and is in the process of being cleared through customs,

ix) Progress photographs of significant events. The Employer may direct the inclusion of specific photographs if deemed necessary,

x) Main items of temporary facilities constructed during the reporting period,

xi) A statement detailing the status of progress on the overall program and how to regain any lost time or setbacks, which may have occurred,

xii) A list of inoperable temporary equipment, and the estimated date when the repair will be completed,

xiii) A statement about labour relations & an explanation of an actual or potential problems,

xiv) A listing of each accident at the site involving the hospitalization and/or death of any person,

xv) A listing of the amount & date of any payments received during the reporting period & the amount of any monthly invoice, which has been submitted but not yet paid,

xvi) A list of claims (if any) submitted during the reporting period including the claimed cost & extension of time,

xvii) A statement concerning potential problems and recommendations on how they could be resolved.

2.14 Technical Documentation

All the technical documents and drawings required to be furnished under this contract as per clause 2 “General Technical Specifications (GTS)” shall be prepared in internationally accepted software of latest version used for preparation of documents and drawings.

The Bidder shall submit six (6) copies (or as required) of drawings along with copy in electronic form media for approval/review as per clause 1.8 of “Particular Conditions of Contract”. At the time of completion of contract, the Bidder shall submit ten copies along with two reproducible and five copies in electronic form in DVD media, of approved and as built drawings together with operation and maintenance manual as specified “Particular Conditions of Contract”.

All the drawings and documents shall be submitted in presentable folders properly bound and catalogued for easy retrieval/reference. Drawings shall be submitted in A0/A2/A3 and all documentation in A4 size. All drawings shall be digitally printed/ plotted. Ammonia print/blueprint shall not be accepted.

3 Spare Parts and Tools

3.1 Spare Parts

All spare parts to be supplied shall be interchangeable with the corresponding parts of all the Works supplied under these Specifications and shall be of the same material and workmanship. They shall be replaceable without cutting or destruction of adjacent components. Before issue of the Taking-Over Certificate the spare parts shall be checked at the Site by the Bidder in presence of the Employer.

Acceptance of any spare parts will not take place before the Bidder has submitted the complete final detailed list of all spare parts and tools.

All spare parts shall be protected against corrosion and shall be marked with identification labels in the English Language. The identification shall be in accordance with the agreed Works Identification System.

All spare parts, tools and materials shall be delivered in marked boxes of sufficient sturdy construction to withstand long term storage.

3.1.1 General Spare Parts

At least the quantity of general spare parts specified below shall be included in the Total Contract Price and consequently in the scope of Works of the Contract.

If the same spare parts are listed twice under "General Spare Parts" as well as under "Specified Spare Parts", the quantity listed under "Specified Spare Parts" shall take priority over the quantity stipulated under "General Spare Parts".

i) **Spare Parts for Wear and Tear Items**

For each installed assembly such as Servo motors, Pumps, Motor, Main Inlet Valve, Pressure Oil Units, Gate Valves, Compressor, Crane, Machine Tools etc. the following general Spare Parts shall be delivered.

Two (2) complete sets of:

a) Facing rings of mechanical seals,
b) Protection sleeves,
c) Carbon brushes for motors (if applicable),
d) Inserts of filters,
e) Wearing bushings,
f) Brake liners,
g) Packings,
h) Roller bearing for rotating shafts and seals for rotating shafts,
i) Driving belts (if applicable),
j) Wearing parts of couplings,
k) Frequently actuated springs.

Wear and tear items shall be defined as such, which require replacement several times during the service life of the assembly.

ii) **Customary Spare Parts**

For a number of like and identical assemblies the following spare parts shall be delivered, whereas one set shall be defined as the total quantity for one assembly:

"X" Complete Sets related to "Identical Assemblies":

a) Seals, gaskets and packing,
b) Thermometer, manometer, flow meter, level indicator (with and without contacts),
c) Transducer 4-20 mA for position, pressure, temperature, flow and any other parameters,
d) Lamps, signal lamps, push button and switches,
e) Fuses, clamps,
f) Limit switches, auxiliary relays, pressure switches,
g) Roller bearings, sleeves and bushings for movable parts including for spherical joints,
h) Resistance thermometer without indicator,
i) Motor-starters, contacts for feeder switches,
j) Springs.

Related to "Identical Installed Standard Valves and Gates" (manually, hydraulically or electrically driven) including Drive like.

"X" Complete Valves and Gates:

a) Shut-off valves and cocks,
b) Globe valves, needle valves or butterfly valves,
c) Non-return valves,
d) Pressure relieve valves,
e) Pressure reducing valves,
f) All solenoid valves,
g) Safety valves,
h) Aeration and venting valves,
i) Float controlled valves,

The quantity "X" which shall be furnished is a function of the number "N" of supplied "Assemblies" or "Valves and Gates" identical in type and size:

$N < 5$, $X = 1$

$N < 10$, $X = 2$

$N > 10$, $X = N/10 + 1$, rounded up to the next higher whole number. The Contractor shall provide 5%, but at least two pieces of all bolts, screws, nuts, washers, spanner rings and cotters. The quantity may be taken from the surplus handed over to the Employer after completion of the installation as described under the chapter "Bolts, Screws, Nuts, etc." of this Section.

For all items under this Contract the Contractor shall deliver 5% of the quantity of painting material, but at least one liter, in new sealed containers, for later repair work other than the Contractor's.

Parts with a special size or properties, as listed below are excluded as General Spare Parts:

a) Bolts, screws, nuts, washer, spanner rings and cotters with a nominal diameter of more than 80 mm,
b) Roller bearings, bearing shells, sleeves and bushings for movable parts including for spherical joints with an inner diameter of more than 200 mm,
c) All valves and gates with a nominal diameter of more than 600 mm,
d) Main seals for gates, valves, access doors and openings with a total length of more than 2.40 m in straight length or circumference.

3.1.2 Mandatory Spare Parts

The required specified spare parts are listed separately in the Particular Technical Specifications. The price for each listed spare part shall be quoted individually in the Price List; the total price of spares shall be included in the Total Tender Price.

3.1.3 Recommended Spare Parts

If any additional spare parts are recommended by the Bidder, these shall be stated in quantity and description in the Technical Data Sheets for each item.

Orders for recommended spare parts shall be optional to purchase by the Employer for a period of five (5) years after the date of the completion of the project. However optional spare parts will not be considered in tender evaluation.

3.2 Tools and Instruments

The scope of work shall include all customary and special tools, as well as auxiliary devices including lifting devices, ropes, etc. necessary for total assembly and disassembly of all parts of the supplied Works. Furthermore, the tools for maintenance shall be supplied and included in the Tender. The total price for tools and devices as required by this article shall be included in the specified Price schedule.

The tools, wrenches, etc. shall be unused. Customary tools for erection shall be of the forged and polished chrome-vanadium type. Use of special tools and devices for erection shall be allowed but shall be approved by the Employer in each case. Special tools and devices shall be provided with means for ready identification.

All lifting devices and slings to be used at site shall be tested at works and test certificate shall be supplied to the Employer.

Suitable hardwood or steel boards arranged for wall mounting as well as tool carts and/or toolboxes shall be included in the delivery. An itemized list and description of all provided tools, auxiliary devices, storage equipment, etc. shall be included in the Tender. Acceptance of any tool or device shall not take place before the Bidder has submitted the complete final detailed List of Tools and Appliances.

Ropes, slings etc. shall be handed over in new condition. The Employer shall be entitled to take over from the Bidder the entire erection tools, appliances, instruments at mutually agreed conditions.

3.2.1 Special Tools

Special Tools shall be supplied by the Bidder as necessary for erection, installation, testing, commissioning, soperation and maintenance, etc. of each item of equipment supplied under this Contract.

Special tools shall include tools specified by the Employer and those others recommended as necessary and accepted at the time of award of the contract.

All special tools shall be clearly marked to identify their use and shall be made available for the erection to be undertaken by the Bidder. Special tools shall be shipped with the first consignment of equipment to be erected.

The tools shall be delivered to the Employer prior to taking over, in perfect condition or be replaced, if necessary, with new tools of equal or better quality than the original ones.

3.2.2 Tools/Devices for Erection, Testing and Acceptance

The Contractor shall bring his own tools, devices, instruments/equipment for site testing in order to erect and install the complete equipment delivered under this section. The testing equipment shall be subject to acceptance of Owner.

These shall remain the property of the Contractor unless otherwise agreed to take over any/all of these at mutually agreed conditions.

For on-site assembly, the Contractor shall use the same assembly tooling and procedures as those used in the shop.

4 Design and Manufacture

4.1 General

Design, manufacture and construction requirements shall generally be as described below besides complying with the specific requirements elaborated in particular technical specification.

4.2 Design and Construction Requirements

The following directions, information and technical requirements for layout, design and manufacture shall be observed as far as they are applicable to the Works to be offered. The technical requirements of the General Technical Specifications are valid for all parts of the Works except where they are modified by additional and/or special requirements, specified in the Particular Technical Specifications.

Any changes of the design of any part of the Works, which may become necessary after signing the Contract, have to be submitted in writing to the Employer for approval, being sufficiently substantiated and justified.

The parts of the Works shall be designed and arranged so that they can be easily inspected, cleaned, erected and dismantled without involving large scale dismantling of other parts of the Works. They shall be designed, and manufactured in accordance with the latest recognized rules of workmanship and modern engineering practice

The regulations, standards and guidelines listed in these Specifications shall be observed in the design, calculation and manufacture of the Works.

All parts of the Works shall be suitable in every respect for continuous operation at maximum output efficiency under the climatic conditions and operating conditions prevailing at the Site.

Special attention shall be given to Works, parts of which are delivered by different manufacturers. Problems arising in this connection shall be solved by the Bidder and be defined in writing.

All live, moving and rotating parts shall be adequately secured in order to avoid danger to the operating staff.

Manufacturers shall take appropriate measure to prevent the ingress of dust into any Works (such as bearings, relays, control and measuring equipment, etc.), which may be endangered thereby.

Suitable lifting eyes and backing-out bolts shall be provided where required or where they will be useful for erection and dismantling.

All design details and layout matters shall be discussed in periodic meetings with the Employer. The first design meeting between the bidder and the Employer shall take place within 60 days after the date of signing of the contract or placement of the order. Further design meetings shall take place as agreed between the participants until the design work is completed.

4.2.1 Design Criteria

The following design criteria shall be considered mutually complementary of one another and shall be applied by the Bidder to all aspects of the equipment and services supplied under this Contract. The plant equipment shall be designed for the worst possible combination of the following loading conditions as applicable:

i) All static and dynamic hydraulic loads,
ii) All loads due to dead weight and frictional forces,
iii) Seismic or wind loads, and
iv) Other loads.

4.2.1.1 Studies for Design Parameters

The requirement for various equipment have been specified in different sections of the bidding document. However, the Bidder is required to carry out the following studies and undertake design of various equipment based on the result of such studies:

i) Location of lightning arrestors at various sites in powerhouse and pothead yard,
ii) Insulation co-ordination,
iii) Earthing studies for various equipment,
iv) Other studies necessary for designing various equipment.

Reports of all such studies shall be submitted for approval of the Employer.

The Bidder shall furnish the drawings for various location for equipment earthing to the civil contactors for execution.

4.2.1.2 Maximum Allowable Stresses

i) General

The layout of the parts of items of works shall fundamentally consider the most severe conditions to which they will be subjected during testing and operation.

If different stress values are given in the General/Particular Technical Specifications or in the relevant standards and regulations, then the more stringent values shall be applicable.

The dimensions of the parts which are exposed to repetitive and alternating stresses as well as to impacts and vibrations shall take into account the safety measures approved in practice.

While designing parts subjected to alternating stresses, vibration, impact, or shock, adequate safety margins are to be considered.

While designing parts subjected to alternating stresses, vibration, impact, or shock, adequate safety margins are to be considered.

Horizontal seismic coefficients for this project has been considered as 0.24 g. The vertical seismic design coefficient is considered as 2/3rd of the horizontal seismic design coefficient which works out to be 0.16 g. Under the most severe conditions of loading expected in normal operation, stresses in the materials shall not exceed the values listed below except that appropriately lower values shall be used where loading characteristics could cause fatigue failure or excessive deflections. Maximum design stresses for materials not listed shall not exceed one-third of the yield strength or one-fifth of the ultimate strength, whichever is lower.

Generator-Turbine parts including bearings shall also be designed to operate without any damage for at least 30 (thirty) minutes at the maximum runaway speed

ii) Direct or Combined Steady Stresses

i) For materials used in the construction of the equipment, unless otherwise specified, the maximum stress due to maximum normal rated load operating conditions shall not exceed one-third of the minimum yield point or one-fifth of the minimum ultimate strength of the material, whichever is lower.

ii) Maximum unit stresses in rotating parts of the turbine due to maximum runaway speed or in parts under hydrostatic test conditions shall not exceed two-thirds of the minimum yield point.

iii) Maximum unit stresses in rotating parts of the generator due to maximum runaway speed shall not exceed three-quarters of the minimum yield point.

iv) Maximum unit stresses in parts of that equipment, which is subject to the maximum normal operating conditions, shall not exceed the values in the following table:

Sl. No.	Material	Material allowable stresses	
1		In Tension	In Compression
2	Gray cast iron	1/10 U.T.S	70 Mpa
3	Carbon cast steel and alloy cast steel	The lesser of 1/5 U.T.S or 1/3 Y.S	The lesser of 1/5 U.T.S. or 1/3 Y.S.

4	Carbon or alloy steel forgings or alloy steel plates for principal parts	1/3 Y.S.	1/3 Y.S.
	U.T.S = Ultimate Tensile Strength		
	Y.S = Yield Strength		

v) Maximum stresses in shear shall not exceed 21 MPa in cast iron, nor 60% of the allowable stresses for other materials, except that the maximum shear stresses in the turbine / generator main shafts and shut-off valve stems shall not exceed 50 % of the allowable stress in tension.

vi) Thermally or hydraulically pre-stressed bolts such as coupling bolts, bolts for connecting of Butterfly valve body halves, bolts for pre- tensioning of Generator-stator metal sheets etc. are exempted from the limitations imposed and stresses up to 80 % of Yield stress are allowed in such cases.

vii) Parts subject to water pressure shall be designed to the applicable provisions of ASME Code and welding shall be as specified herein and in accordance with ASME Boiler and Pressure Vessel code Section 8, Division 2.

iii) **Stresses in Standard Products**

Standard products are not subject to the above conditions i.e. will not be custom designed. Such products are for example:

i) Drainage water pumps,
ii) Cooling water pumps,
iii) Air compressors,
iv) Fans, AHUs, Chillers,
v) Other similar products.

iv) **Loads on Foundations**

Supplier shall determine maximum forces emanating from normal/emergency operation of the equipment, acting upon equipment foundations or upon adjacent structures. The Supplier shall guarantee that those forces will not be exceeded.

4.2.1.3 Water Characteristics

Water of Khorlochhu River carries high sediment load during monsoon. The characteristics of the water at Dam site KHPL are as follows:

i) Maximum temperature - 30°C
ii) Minimum temperature - Below freezing temp.

The report on petrographic analysis of silt in water and chemical analysis of water is appended at the end of this section as "**ANNEXURE-III**".

4.2.1.4 Silt Erosion Consideration

The project is situated in Himalayan region where the silt content during high flow period is excessive and peaks abnormally during high flood. The underwater components may be expected to operate under silt concentration more than 3000 ppm.

4.2.1.5 Atmospheric Condition

The temperature and humidity in the area of the project are as follows:

i) Maximum temperature : 35 °C
ii) Minimum temperature : 2.0 °C
iii) Maximum relative humidity : 100%
iv) Minimum relative humidity : 20%

However, the data shall be subject to final verification during detail engineering.

4.2.1.6 Seismic Design

Khorlochhu project and its neighborhood area lies in close proximity to the north-eastern region of India, which falls in zone V of seismic zoning map and has been affected by moderate to high intensity earthquake in the past. Value of peak ground acceleration has been recommended as 0.24g for Maximum Credible Earthquake (MCE) and 0.16g for Design basis Earthquake (DBE).

The forces being caused by earthquake including hydraulic loads, which may occur additionally, shall be taken into account for the computations. Stresses resulting after including these loads shall not exceed permissible stresses.

The Bidder shall design all equipment supplied under this contract to satisfy the seismic criteria. The Bidder shall submit to the Employer the method of calculation and relevant codes he intends to use for this purpose.

In addition to the above, the IS 1893 shall be adopted for seismic design. Hydrodynamic forces due to seismic conditions shall be considered on HM or EM equipment in addition to hydro static loads.

4.2.1.7 Noise

The noise level caused by the installed Works shall not exceed the following values if not otherwise stated in the Particular Technical Specifications:

i) Machine hall, workshops, etc. max. 85 dB (A) at any place 1 m distant from operating equipment.

ii) Offices, control rooms, max. 55 dB (A) rooms, canteens, etc.

The noise level definition and measurement shall be in accordance with ISO. The values stated shall be adhered to taking a normal civil construction into account.

4.2.1.8 Transportation Limitations

For shipments, the Manufacturer shall pack the items to meet size and weight restrictions of the Indian railways and Indian / Bhutanese road systems.

Shipments from Manufacturer's work (in case offshore consignments) shall travel to Port of entry – India, from where these will be transported, after necessary port clearances etc., by the Bidder to nearest rail head for the Project and further transported to site. However, in certain cases the Bidder may be required to transport the materials from Port of entry to Project site directly by road transport. For onshore consignments, the Bidder shall be responsible in all respects for transportation of all material and equipment up to the project site.

The bidder shall conduct the detailed road/route survey before the design/manufacturing so as to ascertain the transportation limitation. The bidder shall submit the report of such survey highlighting the details of bottle neck or inadequacies in the existing roads/bridges, if any, to the employer within six (6) months from the date of notification of Award.

The Bidder shall consult with the concerned authorities in railways and highways to ensure that his packaging will be such as to permit him to transport the plant and equipment within such imposed limits. The Bidder shall arrange to deliver the maximum sized sub-assemblies consistent- with safe and convenient transport.

All materials and equipment etc. arrived at nearest railhead for the Project will be unloaded from rail wagons and reloaded on to road transport for shipment to project site by the Bidder.

All components shall be so designed and constructed as would enable easy assembly of components at works and at the same time permit easy transportation. The weights

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and sizes of the components/packages shall be within the permissible transport limits for the project site.

The maximum weight and dimension that can be transported to the project site has to be authenticated by the bidder.

4.2.1.9 **Equipment and Facilities Layout**

As shown in drawings supplied by the Employer, the Employer has established, his own purposes, a preliminary layout of the facilities.

The Bidder shall verify and submit to the Employer, arrangement and layout, optimized for the actual equipment supplied under this contract, respecting the key dimensions, elevations and concrete outline of the powerhouse that shall remain same as shown in contract drawings and confirm the same in "Data Sheets".

4.2.1.10 Availability and Reliability

The Contractor shall design each equipment system or subsystem to provide a high level of availability and reliability. The "Electrical & Mechanical Works" shall be designed, constructed and integrated using components and systems which have been proven in other plants of similar application and have shown low failure rates in such applications.

4.2.1.11 Maintainability

All verifications and inspections recommended by the Contractor for the correct functioning of the equipment (thermometer readings, equipment lubrication, greasing and oil level readings) shall be possible under normal conditions of accessibility.

i) **Frequency of maintenance interventions**

The Contractor shall optimize the various system and subsystem to provide the desired availability and reliability while minimizing their maintenance requirements. Routine calibrations shall not be required more frequently than once a year.

ii) **Interchangeability and consistency of parts**

The Contractor shall optimize the various system and subsystem to minimize the number of different components and associated spare parts. Equipment fulfilling the same or similar functions at various locations shall whenever possible use the same material.

Homologous parts shall be interchangeable without needing any adjustments.

All equipment, parts and elements of mass production shall be standardized. These pieces of equipment, parts and elements shall include but not be limited to: motors, pumps, flanges, bolts, nuts and threads, valves, gauges and detectors, electrical instruments and measuring devices, flow meters, terminal and terminal boxes, primary, secondary and auxiliary relays, contactors, fuses and switches, lamps, bulbs sockets push buttons, lubricants, control modules, I/O modules, etc.

Where the equipment supplied under this Contract comprises identical pieces of equipment each of their corresponding removable parts shall be fully compatible and interchangeable for use in the other, without adjustment to the remaining parts.

The Contractor shall coordinate the supply of his sub-contractors to achieve a great degree of standardization throughout the "Electrical & Mechanical Works" and the stock of spare parts.

4.3 Standardization of Works

Every effort shall be made to standardize parts and minimize costs of the Works throughout the Works in order to facilitate keeping stocks, maintenance, replacement, interchangeability, etc.

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The Employer, therefore, reserves the right to request the different bidders to use uniform types or makes of works & materials. The bidder shall not be entitled to claim extra payment due to this request. This request shall especially be applicable to small mechanical and electrical works such as:

i) Valves,
ii) Thermometers,
iii) Pressure gauges,
iv) Flow meters,
v) Water level gauges,
vi) Terminals& terminal racks,
vii) Indicating instruments & meters,
viii) Auxiliary relays,
ix) Fuses
x) Motor protection switches,
xi) Control devices,
xii) Lights, Fixtures, plugs, sockets,
xiii) Limit switches,
xiv) Level switches.

The types or makes to be used shall be decided later by the Employer. All instrument scales shall be written in the ruling language of the contract and in the international SI- System of units.

4.4 Quality of Materials and Works

For general requirements concerning the quality of materials and Works, the applicable sections of the "Particular Technical Specifications (PTS)" may be referred.

4.4.1 Fastening Elements for Equipment

i) Fastening elements for the equipment viz. the bolts, studs, nuts, screws, washers shall be of material most suited for the operating condition and the frequency of removal for dismantling of the respective components, parts. These items shall conform to relevant Indian or international standards.

ii) The fastening elements shall be of following materials depending upon the condition of operation:

a)	Submerged in water	: Corrosion resistant stainless steel as per applicable grades
b)	Subjected to regular removal for dismantling for maintenance or frequent adjustment	: Corrosion resistant steel as per applicable grades
c)	Subjected to less frequent dismantling	: High tensile steel/ other suitable material as per practice.

iii) The fasteners (nuts and bolts) for the parts subjected to pressure shall be machined on the shank, under the head and nut.

iv) Where necessary, the fastening elements shall have locking devices and anti-vibration devices and washers shall be of the taper type.

v) Where there is risk of corrosion, bolts and studs shall be finished flush with the surface of the nuts.

vi) With the exception of high strength friction grip bolts, the bolts shall be designed so that with nuts fully tightened, the stress intensity at the bottom of the thread shall not exceed one half (1/2) of the yield point of the bolt material under all conditions.

vii) In case, nuts and bolts are of manufacturer's own standards, which are different from the usual national or international standards, the bidder shall supply taps and dies for the threads and special spanners for the nuts & bolts.

viii) The bidder shall state the conforming standards for fastening elements indicated in the bid.

4.5 Safety

4.5.1 Safety of Personnel

Where specific standards are not mentioned by the Employer, all equipment and services provided under this contract shall abide by international standards commonly accepted in the hydroelectric utility industry for safety of personnel whether involved with operation or maintenance. All operations and routine maintenance interventions shall be completely safe and designed to be carried out under normal conditions of access and while the equipment is operating.

4.5.2 Safety of Operation

All equipment and services provided under this contract shall abide by commonly accepted standards for safety of operation.

The various system and sub-systems supplied under this contract shall be designed to follow and operate under a clear hierarchical structure:

i) Plant control level,

ii) Unit control level,

iii) Functional control level, functional drive group level,

iv) Local drive level.

Each hierarchical control level shall perform its specific tasks and always depend on the subordinate lower control levels. In general, should a higher control level failure occur, the lower control level shall not be affected and shall be able to control the power plant with full safety.

The Bidder shall accordingly build into the "Electrical & Mechanical System" adequate levels of autonomy, independence, redundancy and functional distribution to insure that safety is maintained at all times.

4.5.3 Handling Provision

Lifting lugs, brackets, eyes, and other items required for attaching lifting devices shall be provided on all the major components of the equipment weighing more than 24 kg for safe handling. All slings and lifting devices required for attachment to the components and assemblies and to a crane hook for safe handling during erection and later disassembly shall be furnished.

4.6 Identification Plates

4.6.1 General

Each important part to be delivered under this Contract shall be equipped with permanent identification plates in readily visible locations. Whether a part shall be considered as important in this respect shall be decided by the Engineer in-Charge.

The identification plates shall be protected during erection and especially during painting. Damaged or illegible identification plates shall be replaced by new ones. The identification plates of non-corroding, non-disintegrating material (except

manufacturer's nameplates of small, standardized components) shall be inscribed in the Contractual language.

The inscription shall be printed, stenciled, or hand-written, but in any case, waterproof, oil-proof and wear-resistant. Works (machines, transformers, etc.) nameplates shall be either of the enameled type or be of stainless steel covered after stamping with a transparent paint. Wording, size and material of all labels and plates shall be subject to the Employer's/ EMPLOYER approval.

4.6.2 Manufacturer's Nameplates

The following data shall be shown in accordance with the relevant standards:

i) Manufacturer's name and address,

ii) Work's serial number and date of manufacture,

iii) Main design data.

As a general rule, standardized components, such as small or medium- sized electric motors, transformers, instruments, etc., may be delivered with the manufacturer's standard nameplate.

The design of the Manufacturer's nameplates for the main components such as gates, cranes, valves, hoists, servomotors, pumps etc., shall be submitted for the Employer's/ EMPLOYER approval sufficiently in advance.

4.6.3 Functional Plates

Each part appearing under a certain symbol or number in functional diagrams, piping diagrams, in the Operation and Maintenance Instructions, etc., shall be equipped with a plate showing the same symbol or number.

4.6.4 Instruction Plates

All plates showing designations or instructions for operation, safety, lubrication, etc. shall have a uniform design.

4.7 Colour Code

4.7.1 Colour Coding For Electrical Connections

Live parts of electrical connections shall be colour coded as follows:

Sl. No.	Conductor Designation	Coding Alpha numeric	Symbol	Colour
1	A.C Network 3 Phase	Phase1	R	Red
		Phase2	Y	Yellow
		Phase3	B	Blue
		Neutral	N	Black
2	A.C Network Single Phase	Phase	P	Red
		Neutral	N	Black
		Earth	E	Green yellow
3	D.C Network	Positive	a	Red
		Negative	b	Black

4.7.2 Colour Coding for Mimic Diagrams

Mimic diagrams to be arranged on switchgear cubicles, control panels/desks, etc. shall be colour coded as follows:

132 kV/220kV/400kV : Gold

11 kV	:	Red
415 V	:	Black
220 V DC	:	Violet
48 V DC	:	White

4.7.3 Colour Coding for Mechanical Items

Color coding proposed for the mechanical items are as follows:

Turbine casing	:	Pebble gray (RAL 7032)
Spherical valve	:	Mint. Green (RAL 6029)
Air compressor system	:	Sky blue (RAL 5015)
OPU	:	Yellow Orange (RAL 2000)
Pumps	:	Mint. Green (RAL 6029)
Lube oil plant	:	Light grey (RAL 7035)
Oil pressure piping	:	Yellow orange (RAL 2000)
Lubricating oil piping	:	Yellow orange (RAL 2000)
Firefighting water piping	:	Traffic red (RAL 3020)
Air piping	:	Sky blue (RAL 5015)
Insulating oil piping	:	Yellow orange (RAL 2000)
Cooling water piping	:	Yellow green (RAL 6018)

Note:

Colours mentioned above shall be finally agreed upon during detailed design. The colour code for equipment not listed in the above mentioned specifications shall be agreed upon after award of the Contract. The colouring of pipelines, moving parts, etc., shall be according to internationally recognized standards.

4.8 Workmanship

The Contractor shall level and adjust all parts of the equipment on the foundations and after each item is set up and the Engineer's approval obtained, grouting or concreting will be carried out by other contractors and verified by the Contractor. The Contractor shall be responsible for ensuring that such work is carried out to his satisfaction and that level and adjustments made by him are not disturbed by the grouting operation. The Contractor shall be responsible for ensuring that the positions, levels and dimensions of the Works are correct according to the drawings notwithstanding that he may have been assisted by the Engineer in setting out the said position, levels and dimensions.

4.8.1 Finished Surfaces

Surfaces to be machine-finished shall be indicated on the shop drawings by symbols. Compliance with the specified surface shall be determined by the sense of feel and by visual inspection of the work compared to applicable "Standard Roughness Specimens", or with roughness feeler gauge instruments. Both "Standard Roughness Specimens" and feeler gauge instrument shall be procured by the Contractor at the request of the Engineer.

4.8.2 Unfinished Surfaces

As far as practicable, all work shall be laid out to secure proper matching of adjoining unfinished surfaces. Where there is a large discrepancy between adjoining unfinished surfaces, they shall be chipped and ground smooth or machined to secure proper alignment.

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Unfinished surfaces shall be true to the lines and dimensions shown on the drawings and shall be chipped or ground free of all projections and rough spots. Depressions or holes not affecting the strength or usefulness of the parts shall be filled in a manner approved by the Engineer.

4.8.3 Protection of Machined Surfaces

Machine-finished surfaces shall be thoroughly cleaned of foreign matter. Finished surfaces of large parts and other surfaces shall be protected with wooden pads or other suitable means. Unassembled pins or bolts shall be oiled or greased and wrapped with moisture-resistant paper or protected by other approved means.

4.8.4 Rounding, Chamfers, Edges

The edges of surfaces to be painted shall be rounded (minimum radius 2 mm) or chamfered accordingly. This requirement must be stated in all shop drawings for the relevant parts.

4.8.5 Flame Cutting

i) Low carbon structural steel may be cut by machine-guided or hand-guided torches instead of shears or saws. Flame cutting of material other than low carbon structural steel shall be subject to the approval of employer and, where proposed, shall be definitely indicated on shop drawings submitted by the bidder. Where the torch is machine-guided, no chipping or grinding will be required except to remove slag and sharp edges.

ii) Flame gouging will be permitted as a preparation for welding. Where the torch is hand-guided, the cut shall be chipped, cut, or machined to sound metal except where material is not to be welded, in which case the burrs and rough edges alone shall be removed.

4.8.6 Machine Work

i) Unless otherwise shown on the approved shop drawings, all tolerances, allowances, and gauges for metal fits between plain (non-threaded) cylindrical parts shall conform to applicable ISS, ANSI Standard B.4.1 or DIN 7157 for the class of its as shown or otherwise required. Sufficient machining allowance shall be left on placing pads to ensure true surface of solid material. Finished contact or bearing surfaces shall be true and exact to ensure full contact.

ii) All machined parts shall be accurately machined and like parts shall be interchangeable. Drilled holes for bolts shall be accurately located and drilled to templates when necessary or specified. The holes for fit-up bolts or dowels shall be carefully reamed and the bolt or dowel shall enter with a light driving fit. Bolt and screw threads shall conform to applicable ISS or to ISO standard R68.

4.8.7 Surface Finish

Surfaces to be machine-finished shall be indicated on the shop drawings by symbols, which conform to ANSI B46.1. Values of roughness height are specified in microns as "average deviation from the mean surface". Values of roughness, width and waviness height are not specified but shall be consistent with the general type of finish as specified by the roughness height. Compliance with the specified surface will be compared to roughness comparison specimens.

Type of Finish and Roughness Value

i) Surfaces which are to be machined to dimensions where the tolerance is 0.5 mm or greater shall have a maximum roughness value of 12 microns.

ii) Stationary mating surfaces, where reasonably accurate positioning of the members or a moderately tight joint is desired, shall have a maximum roughness value of 6 microns.

iii) Surfaces in sliding or rotating contact, where motion is slow and loads are light, shall have a maximum roughness value of 3 microns.

iv) Surfaces in sliding or rotating contact, when loads and speeds are moderate, shall have a maximum roughness value of 1.6 microns.

v) Surfaces in sliding or rotating contact, where loads are heavy and/or the motion is rapid, shall have a maximum roughness value of 0.8 microns.

4.8.8 Templates and Gauges

All parts that may require renewal shall be made to template and gauge so that original and spare parts will be interchangeable. One set of all special gauges and templates necessary for site erection and runner maintenance shall also be supplied which shall become the property of employer.

4.8.9 Structural Work

Design and fabrication of structural parts shall conform to the applicable provisions of the DIN standards, including DIN19704-Hydraulic steel structures: criteria for design and calculations and DIN 4114 - Stability of steel structures, unless otherwise prescribed elsewhere in these Specifications. Dimensions with free tolerances shall be governed by “medium” class of DIN7168.

4.8.10 Casting

1.1.1.1 General Requirement

Castings shall be free from injurious defects and shall be free of foundry irregularities such as projections, ridges, hollows, honeycombing, pock marks, or chip marks, so that they will not require surface smoothing operations in the field prior to painting. The location of existing defects shall be determined, and they shall be completely removed to sound metal. The structure of the castings shall be homogenous and free from excessive non-metallic inclusions. An excessive segregation of impurities or alloys at critical points in a casting will be cause for its rejection. All castings involving welded fabrication shall be stress-relieved.

i) **Inspection and Repair**

a) The bidder shall notify employer in ample time to have an inspector present at the foundry, if employer so desires, when the castings are cleaned and defects if any, chipped to sound metal, before any repair welding is done. After the repairs of castings, same shall be heat-treated.

b) Test pieces for tension and bend test specimens shall be removed from the castings at the time of inspection. Certified copies of the test reports shall be furnished to the employer. The bidder shall make non-destructive tests for important load carrying castings as appropriate prior to final machining. Radiographic or magnetic particle inspection, ultrasonic or other non-destructive tests, may be required by purchaser when it is desired to make such tests as a means of judging acceptability of castings which contain defects of apparent borderline seriousness or to determine that repair welds have been properly made. Any such tests shall be at the expense of the bidder.

ii) **Inspection and Repair**

a) No repairs of major defects shall be made to castings without prior approval from purchaser. Defects shall be considered major when the depth of the cavity properly prepared for welding exceeds 20 percent of the wall thickness or 25 millimeters, whichever is smaller.

b) Welding of defects shall be performed only by qualified welders or welding operators and shall conform to the best modern welding practice.

c) If the removal of metal to uncover a crack or remove a defect reduces the stress-resisting cross-section of the casting to such an extent that the computed unit stress in the remaining metal is less than 30 percent in excess of the allowable stress, the casting may, at the option of purchaser, be rejected.

d) Casting repairs by welding of major defects at any stage of manufacture after the first heat treatment (annealing) shall be stress relieved. Minor defects or imperfection that will not ultimately impair the strength or service ability of the castings, may be repaired by welding in accordance with accepted commercial casting practice without securing approval. However, an accumulation of minor defects which in the opinion of purchaser casts serious doubt as to the general quality of the casting may constitute cause for rejection.

iii) **Dimensions**

Thicknesses and other dimensions of the castings shall conform substantially to the dimensions on the drawings and shall not be reduced by shop or foundry practices to the extent that the resulting stresses in the metal will exceed the stresses allowed under these specifications. Castings shall not be warped or otherwise distorted, nor shall their dimensions be oversize to such an extent as to interfere with proper fit with other parts.

iv) **Surface Finish**

a) Surface finish shall be indicated on the detail drawings and shall conform to the requirements of ANSI B46.1 "Surface Roughness, Waviness and Lay", or other approved equal standard.

b) All parts shall be free from burrs, sharp edge and imperfections in cutting, machining and welding. All visible parts shall receive special attention in order to ensure pleasing appearance of the completed machine.

4.9 Welding and Heat Treatment

4.9.1 General

All welds shall be as shown in detailed drawings and shall be made in such a manner that residual shrinkage stresses will be reduced to a minimum.

The Contractor shall submit adequate information concerning the proposed:

i) Extent to which automatic welding techniques will be applied,

ii) Extent to which manual welding techniques will be applied,

iii) Extent to which it is the Contractor's intention to use pre-weld heat treatment, post-weld stress relieving, full anneal stress relieving or normalizing consistent with the thickness and types of material proposed,

iv) Weld electrodes, welding wire and flux which will be used with the selected plate material or materials,

v) Standard tolerances for the deviations of mating weld profiles.

4.9.2 Welding

Pieces to be joined by welding shall be cut accurately to size including the required allowances. According to the proposed welding method, the welding edges shall be sheared, flame-cut or machined to allow thorough penetration and fusion of the weld with the base material.

The cut surfaces shall be free of all visible defects, such as laminations, surface defects caused by shearing or flame-cutting operations. The edges and surfaces to be

welded shall be free of rust, mill scale, grease, oil, paint or any other foreign matter. Welding over zinc primers shall be permitted subject to submission of a certificate of a recognized institution stating the pertinent limiting parameters for this welding procedure. In all other cases, welding over paint shall be prohibited; all painting materials next to the joint to be welded shall be removed well beyond the heat affected zone.

Unless otherwise allowed by the Engineer, all steel parts to be welded shall be manufactured of steel produced by the open hearth or electric, with carbon content not higher than 0.20 % and a phosphorous content of not more than 0.05 %.

Wherever welding is specified or permitted, a welding process in line with ASME section VII or DIN standard shall be used. However, approval of the welding process shall not relieve the Contractor of his responsibility for correct welding, the use of correct electrodes and for minimizing distortion in the finished structure.

When the welding process has been approved by the Engineer, the Contractor shall produce a record drawing to show the approved process. The drawing shall include details such as the form of edges to be welded, electrodes and other welding materials, welding sequence, etc. Changes in the welding process after the welding method has been approved shall require the consent of the Engineer.

Where possible, welding shall be carried out in the workshop. Welding which has to be performed in the field shall be clearly so indicated on drawings.

The Contractor shall follow the steel manufacturer's recommendations concerning electrodes, welding and material pre- and post-heat treatment.

Notwithstanding the above, the suitability of the electrodes to be used for welding and the welding methods to be used for both shop and field welding shall be demonstrated by trials and tests to the satisfaction of the Engineer.

Additional copies of all records of all welding procedures, including preheating and stress relieving, chemical analysis and physical properties, shall be made available to the Engineer upon request.

Design, preparation, performance and testing of welded constructions shall suit the kind of stresses and the grade of risk, considering a supposed failure of the welded member.

The following table shows a general classification by means of numbers with the signification of each number explained thereafter.

Any structure not especially mentioned shall be classified by the Contractor and shall be subject to approval by the Engineer.

STRESS				
Sl. No.	**Risks**	**Compression**	**Bending**	**Alternating Dynamic Tension>0.9 allowable stress**
1	Small risk: Stairs, Rails, Doors	0	0	1
2	Medium risk: Cranes, Trusses, Bridges	4,1	4,1	7,4
3	High risk: Penstocks, Steel Linings, Spiral Casing, Stay Vanes, Runner, Gates, Stop Logs etc.	5,6,7,8,2,4	5,6,7,8,2,4	5,6,7,8,2,4

0 = without special prescriptions. Only skilled and tested welders shall be employed which shall follow proven rules of workmanship.

1 = Full penetration welds. The weld preparation shall allow the filling of the weld profile without defects. The root of double welded butt joints shall be ground before welding the second side. If the second side is inaccessible for welding, such single welded butt joints shall be built up against a backing strip.

2 = Weld ground flush. The weld shall be ground on both sides of the steel plate. The weld surface shall be finished so as not to reduce the plate thickness by more than 3%. Butt welds with a smooth surface and a champher of less than 8% of the width of the top layer need not be ground.

3 = Connections rounded. Where stresses are to be deviated, already the design shall care for a reduced notch effect. Welds shall be smoothly ground and rounded.

4 =Welder qualification test. All welders and welding operators shall have passed qualification test in accordance with the respective National Standard or rules of AWS-American Welding Society, or the DIN EN 287.

5 = Welding procedure test. The Contractor shall describe the proposed welding procedure. Further he shall prove with tests, that the properties of the weld and transition zone are at least equal to those specified for the base material.

The welding procedure test may be combined with the welder's qualification test.

6 = Welding performance test, executed during fabrication and site welding. Run-off plates shall be tack-welded to one end of the plate under work. The weld shall continue on that run-off plate (test plate), welded in the same manner and under normal working conditions.

One test plate is required every 20 m of weld seam, but at least one of each weld type.

The laboratory tests shall cover the same range as the welding procedure tests.

On request by the Engineer test plates shall be welded in his presence.

7 = Ultrasonic and/or radiographic test. Depending on the location of the weld seams and the plate thickness, ultrasonic and/or radiographic tests shall be performed. The Contractor shall submit a proposal subject to approval by the Engineer. If not stated differently in the Detailed Technical Specifications, 20% of the weld length shall be radiographed, but at least one film per weld type. The Contractor shall record the results of the ultrasonic and/or radiographic testing in these reports and drawings.

8 = Marked with welder's stamp. The welder shall mark every seam welded by him with his number, so it can be recognized until the end of the fabrication period.

4.9.3 Preparation for Welding

Members to be joined by welding shall be cut accurately to size, with edges sheared, flame-cut, or machined to suit the required type of welding and to allow thorough penetration and good fusion of the weld with the base metal. The cut surfaces shall be free of all visible defects such as laminations, surface defects caused by shearing or flame cutting operations, or any other injurious defects. The surfaces of plates to be welded shall be free from rust, grease, and other foreign matter along the edges prepared for welding as per relevant IS.

4.9.4 Welding Codes

All welding for the fabrication of principal stress-carrying parts shall be in accordance with the latest version of IS 2825 or to Part UW of Section VIII of the American Society of Mechanical Engineers (ASME) "Boiler and Pressure Vessel Code", with the exceptions regarding stress-relieving stated below. All welding for the fabrication

of other parts shall be in accordance with the applicable requirements of paragraphs 401 through 403 and 406 through 410 of the "Standard Code for Arc and Gas Welding in Building Construction" of the American Welding Society (AWS) or other equivalent approved standard including ISS.

4.9.5 Welding Qualifications

For welding of principal stress carrying parts, the standard of welding procedures, welders and welding operators shall conform to standards equivalent to the requirements of the ASME Boiler and Pressure Vessel Code, Sections VIII and IX, or DIN 8560, DIN 8563, EN 287.

For welding of other parts, the qualifications, welders, and welding operators shall conform either to Section IX of the ASME "Boiler and Pressure Vessel Code", or AWS "Standard Qualification Procedure" or to relevant IS.

All welders and welding operators assigned to the work shall have passed a performance qualification test. If more than one year has elapsed since the welder or welding operator passed his last test, then he shall again be tested. Welders' and welding operators' test certificates shall be submitted to the Engineer.

If at any time, in the opinion of the work of any welder or welding operator appears questionable, such operator will be required to pass additional qualification tests to determine his ability to perform the type of work on which he is engaged. All such additional qualification tests for welding operators and the physical test of the welded specimens shall be made in the presence of purchaser's inspector. All expenses in connection with making such qualification tests for welders and welding operators shall be borne by the bidder.

4.9.6 Welding Work

All welding (except welding of thin plates or piping of small sizes) shall be performed by the electric-arc method and where practical, with process controlled automatic machines.

The strength of welding of all equipment subject to high and /or alternating stresses, vibrations etc. shall be at least equal to the strength of the parts being weld-jointed.

Between plates and other sections where such stresses are to be transmitted only butt welds shall be permitted. All main butt welds shall have 100% penetration and where possible, shall be welded from both sides. The backside of the first run shall be suitably gauged out to clear metal before the sealing runs are deposited.

Butt welds on site, which can be welded from one side, only shall be provided with back strips on the whole length of the seam to be welded. The back strips shall be fixed to the downstream side of the upper element, to prevent accumulation of water and dirt.

For any welding work, only the appropriate welding rod, either arc or gas, shall be used. The properties shall conform to the material to be welded as specified in the respective standards.

The electrodes for arc welding shall be classified on the basis of mechanical properties of the as welded deposited weld-metal, type of covering, hydrogen absorption, welding position of the electrodes and type of current.

Electrodes shall be used only in the positions and under the conditions of intended use in accordance with instructions with each container. Electrodes for manual welding shall preferably be of the heavily coated type and shall be suitable for welding in any position.

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After being deposited, welds shall be cleaned of slag and shall show uniform sections, smoothness of weld metal, feather-edges without overlap, and no porosity and clinker. Visual inspection of the ends of welds shall indicate good fusion with the base metal.

Where weld metal is deposited in successive layers, each layer shall be thoroughly preened before the next layer is applied.

The difference in thickness of adjacent butt-welded plates shall not exceed 3 mm. where plates of greater thickness are to be welded; a transition with a gradient of 1:5 shall be formed.

Welds shall be balanced as far as possible to minimize distortion and residual stress. Box type girders shall be welded in such a way as to be completely airtight.

All welds transverse to the direction of flow and the longitudinal welds of distributors, shut-off valves and manifolds shall be ground flush with the plates on the inside. Welds shall be ground flush on both the inside and the outside wherever dynamic stress occurs.

Particular care shall be taken in aligning and separating the edges of the members to be joined by butt-welding so that complete penetration and fusion at the bottom of the joint will be ensured.

All pinholes, cracks and other defects shall be repaired by chipping or grinding the defects to sound metal and re-welding. Where fillet welds are used, the members shall fit closely and shall be held together during welding.

The ignition of weld electrodes shall not be started at the plate beside the weld, but at the seam flanks to prevent detrimental increments of local hardness. Where ignition points of electrodes are discovered, they shall be ground appropriately.

Where auxiliary structural members are welded to components for the purpose of assembly or installation, these connecting welds shall be given particular care.

These auxiliary structural members shall be removed not by knocking them off, but by burning, followed by grinding the affected areas flush with the plate, without producing additional thermal stresses.

4.9.7 Minimum Weld Requirements

All welds shall be made continuous and watertight. The minimum size of fillet welds shall be 6mm measured on the leg. All butt welds shall be full penetration welds.

4.9.8 Field Welding

The Bidder shall select the proper filler material with respect to parent material for all field welded connections and shall specify it on the applicable drawing, together with the detail design of the field weld joint.

All cutting, chamfering, and other shaping of metals necessary for the field connection shall be done as far as possible in the shop. Adequate temporary bolted field connections shall be provided to hold the assemblies rigidly and in proper alignment during shop and field assembly.

4.9.9 Weld Finish

Welds shall in general be treated so that they will display good appearance and a surface suitable for painting. Structural welds shall be ground and blended to avoid stress raisers. All welds, which require non-destructive examination, shall be dressed by chipping and grinding as required for good interpretation by the selected weld examination method.

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4.9.10 Heat Treatment

The cost of any heat treatment prescribed by the manufacturer of the materials and the Contractor respectively for the welded parts to be supplied shall be included in the Contract Price.

Heat treatment of field erection welding seams shall be performed according to the specifications for the welding procedure for the corresponding parts, which shall be submitted to the Engineer for approval.

4.9.11 Stress-Relieving of Turbine and Generator Parts

For principal stress carrying parts, localized stress relieving will not be permitted for shop-welded parts. All weld-fabricated parts except minor parts, where stress is not important, or which are specifically exempted from stress-relieving shall be stress-relieved as a unit prior to final machining. Radiographic and ultrasonic examination of welds will be required, as specifically stated in these Specifications, and when, in the opinion of employer, doubt exists as to the quality of certain welds. Any such radiographic and ultrasonic inspection shall be at the expense of the bidder. The bidder shall furnish all special materials, equipment, or techniques required for pre-heating or post-heating of members to be joined by field welding.

4.9.12 Stress-Relieving of Turbine Parts

i) **Important Parts** - The design and construction of welded joints shall conform to the applicable requirements of IS: 2825 or the ASME Boiler and Pressure Vessels Code, Section VIII. Machine parts, including all parts directly and permanently attached to the turbine distributor or spherical valve, or pressure shaft butterfly valve shall be stress-relieved prior to final machining.

The stress-relieving furnace shall be equipped with suitable recording thermometers to record the temperature of the furnace and parts during the heating and cooling of the parts. All temperature records shall be submitted to employer for record purposes. Localized stress relieving will not be permitted for shop-welded parts.

Field welding of stress-relieved parts will not be permitted. However, where necessiciated due to transport limitations, the site welding of shop stressed relieved segments shall be permissible. But such welds shall also be locally stress relieved.

ii) **Other parts** - The fabrication of less important parts, such as ‘draft tube cone’, ‘oil sump tank’ etc. shall be in accordance with the applicable requirements of Paragraphs 401 to 403 and 406 to 410 of the American Welding Society. Stress-relieving of such parts is normally not required.

4.9.13 Quality and Procedure Control

Quality control methods, e.g., radiography, ultrasonic crack detection, etc., shall be done in accordance with the appropriate manufacturing code. However, the Contractor shall indicate clearly in the Technical Data Sheets the extent to which these methods shall be used.

All welded joints, which have to be tight, shall be inspected or tested by dye penetration tests.

All major welds carried out on parts under hydraulic pressure shall be tested as per PTS. However, T-joints are 100% radio-graphed. All welds on the skin-plates shall be additional dye penetration tested as directed by the Engineer.

All welds of components subjected to penstock hydrostatic pressure and welds of other important stress-carrying parts shall be 100% radiographically inspected where practical. Where radiographic inspection is not practical, other non-destructive testing

such as ultrasonic, dye-penetrant, magnetic particle, or a combination of tests, shall be used. The results shall be submitted to purchaser for record purposes.

The Contractor shall indicate in the corresponding drawings the type of non-destructive testing to be carried out during manufacture and at Site.

The following or other equivalent Standards shall apply:

For Radiographic Examination:

i) IS: 2825 and IS: 3177 or of the ASME Code for radiograph quality welds.

ii) DIN 54109 Non-destructive Testing; Image Quality of Radiographs of Metallic Materials.

iii) DIN 54111 Non-destructive Testing; Testing of Welds of Metallic Materials by X- or Gamma Rays; Radiographic Techniques.

iv) DIN EN 287 Quality Assurance of Welded Structures; Fusion-welded Joints Steel; Requirements Classification.

v) AD-leaflet HP 5/3 Manufacture and Testing of Pressure Vessels.

For Ultrasonic Examination:

i) According to the approved "Test and Examination Instructions" of the Contractor based on AD-leaflet HP 5/3.

All radiographic films and data shall become the property of the Employer.

Additional non-destructive controls can be required when it is desired to examine the acceptability of any welds when, in the opinion of the Engineer, serious doubt exists as to their quality; in this case, the expense of this examination shall be borne by the Contractor.

When required in the Particular Technical Specifications, the detailed description of welding procedure (including type of welding electrodes, sequence of welding seams, etc.) for certain parts of the delivery shall be submitted to the Engineer before commencement of manufacture.

4.9.14 Defects and Repairs

Plates with laminations discovered after cutting shall be rejected unless the laminated portion is only local and can easily be repaired; such repairs shall require the consent of the Engineer.

Defects in welds will be reported to the Engineer. The Contractor shall use his discretion in determining whether or not it is advantageous to remove and repair the weld. His decision will require approval by the Engineer.

Defects in welds, which are to be repaired, shall be chipped out to sound metal and the areas magnifluxed or ultrasonically tested to ensure that the defective material has been completely removed before repair of welding is carried out. The Engineer shall be informed and given the opportunity of making an examination after the defect has been removed and before repair welding commences. Repairs shall be carried out in accordance with the relevant Standards and to the approval of the Engineer. The Contractor shall be fully responsible for the in-service performance of all welding work.

The Work shall be 100% inspected again by the method used first to determine such faulty work.

4.10 Corrosion Protection

4.10.1 General

The Contractor shall submit full details including the source of the basic raw materials, volatile matter content, nature of solvent, number of components, type of

coat, coverage, time interval between coats and number of coats, compatibility of each coat with the previous coat, toxic properties, physical properties, shelf life, resistance against chemical attack, resistance against ozone and UV-radiation, compatibility with drinking water standards, etc.

It shall describe in detail the treatment he proposes to apply in order to give adequate protection during transport, site storage, building and concreting and subsequent erection.

The different coats of primer and subsequent coats shall be each of different shades of colour where practicable.

The Contractor shall submit to the Engineer for approval an overall colour scheme in accordance with the Particular Technical Specifications/ General Technical Specification, for the finished surfaces of all Works. All final coats shall be in the colours approved by the Engineer. On request of the Engineer, painting samples for the different coats and colours shall be provided.

All pigment, paints and primers shall be delivered to Site in sealed containers packed by the manufacturer. The manufacturer's instructions for preparation and application of all painting and protective coats shall be strictly observed.

Paint materials shall be stored and mixed by the Contractor in strict accordance with the manufacturer's instructions. Paint material shall be used before the expiration of the shelf life. All safety regulations shall be observed, especially with regard to fire.

Annexure I "Painting System", indicates painting materials considered suitable for the various parts of the Works.

4.10.2 Scope of Work

The Contractor's services shall cover the procurement of all materials, and the preparation and application of the painting and other protective coats as specified; all costs shall be included in the Tender Price.

4.10.3 Painting Materials

The Contractor shall provide a complete, reliable coating system. Coating materials shall be standard products of a paint manufacturer with proven experience in the field of corrosion protection of the type of works to be supplied.

The Contractor shall submit for the Engineer's approval full details of the preparation, type of materials, methods and sequences he proposes to use to comply with the requirements for the protection of the Works.

Painting of the repainted surface shall be in accordance to the relevant standard and shall be detailed by the Bidder for Engineer in-Charge’s acceptance

Paint material shall be delivered in unopened original containers bearing the manufacturer's brand name and colour designation, storage directions and handling instructions. The entire paint material for a particular specified paint system shall be supplied by one manufacturer only; who shall guarantee the compatibility and quality of the paint material. A complete list of the proposed paint material shall be submitted to the Engineer. For multicoated painting systems each coat shall have a different colour.

Enclosure-II "Painting Schedule", indicates painting guidelines and materials considered suitable for the various parts of the Works. Painting in respect of standard items shall be acceptable as per manufacturer practice.

4.10.4 Workmanship

i) **Contractor's Equipment**

The Contractor shall observe all safety and health precautions to protect his workers and others. The necessary equipment, such as fans, air-conditioning units, safety masks, nets, etc. shall be provided by the Contractor. All equipment shall be in strict accordance with the respective safety codes and regulations assuring efficient work of high quality.

The Contractor shall be responsible for the collection and disposal of empty containers, dirty rags and other wastes. It shall also be the Contractor's entire responsibility to protect equipment and structures not being painted such as nameplates, instruments, panels, floors, walls, etc. and he shall provide and install all necessary drop cloths and screens.

ii) **Preparation of Paint Material**

Paint shall be delivered ready mixed wherever possible. Adding of diluting agents and mixing of two or multi-component systems shall be done in the field in accordance with the directions of the manufacturer. Mixing and homogenizing of the paint material shall be done by a mechanically driven paddle or agitator in the original container. After mixing, the paint shall be poured into a clean container to ensure that no settled pigments are at the bottom.

The Contractor's equipment shall be of perfect quality and servicing and maintenance must be guaranteed. Cleaning of equipment shall be consistently carried out at each working interval.

iii) **Application**

The most commonly used methods of application are painting by brush, roller, pressure and airless spraying equipment. Selection of the application method depends on the surface to be painted. The quality of the paint shall in no way be negatively influenced. The manufacturer's directions shall govern the choice of application method. Inaccessible surfaces shall be painted prior to erection with primer and finish coats according to the specification. Areas inaccessible to spraying equipment shall be painted by brush. Corners and edges shall be pre-coated. Bolts, screws, studs, rivets etc. shall be painted as a whole with the complete paint system after erection.

The primer shall be applied to an absolutely clean and dry surface only. Temperature and dry-out time shall be in accordance with the manufacturer's directions. Whenever possible the prime coat as well as one intermediate coat shall be applied in-doors at the Contractor's shop.

During painting the air temperature shall be at least +50C and the temperature of the items being painted must be at least 30C above the dew point. During drying of the paint, the temperature shall not be below 00C. For all paints the surface temperature of the metal shall not be higher than +500C during the painting. Instruction and recommendation of paint manufacture may be also be considered and shared with the Owner. Concerning special paints, the requirements set by the paint manufacturer shall be followed.

Cleaning and painting work shall be interrupted outdoors and in non-conditioned rooms under the following conditions: rain, fog, dew, polluting winds, sand and other dusts. Surface preparation and application of the first paint layer are parallel operations to be carried out within a maximum delay of 4 hours.

All painting shall be free of cracks and blisters and all runs shall be brushed out immediately. After application of the last coat the paint system shall be free of pores. After erection of the equipment all damages to painted surfaces shall be repaired. Welds, rusty spots, slags, beads, flux deposits etc. shall be repaired and repainted. For touching up, the same materials shall be used as for the main

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painting work. Repaired finish coats shall be of the same appearance as the original coating.

Remove electrical plates, surface hardware, fittings and fastenings before starting painting operations. Carefully store, clean, and reinstall after completion of work.

Equipment requiring special knowledge, skills and tools shall be prepared to receive field coating and painting to meet requirements of the painting schedule.

Embedded Surfaces:

Cement washed painting of embedded items shall be provided wherever applicable. Embedded surfaces and all attachments to be embedded shall receive one coat of Cement Tex Milk.

Parts, which are embedded in concrete, need not be protected against corrosion. However, transition zones of large steel pipes and of steel linings shall be painted over a length of 1 m within the concrete, all other concreted in steel surfaces over a length of 200 mm within the concrete.

Touch up painting shall be provided before and after erection as applicable. The Contractor shall perform all painting work in the shop, before shipment, followed by a field touch-up during or after installation. If accepted by the Employer, the Contractor may apply the last coat of paint at the site instead of applying it in the shop.

In linings surrounded by concrete, surface preparation and painting works shall be carried out after all Works such as concreting, welding, grouting and cleaning have been completed. The Contractor shall take into account the local climatic conditions and use adequate installations for sandblasting, dust control and sand extraction.

A properly equipped paint shop shall be set up at the Site with a crew of specialists experienced and skilled in the preparation and application of protective coatings, to deal with all site-protective treatment.

4.10.5 Surface Preparation

The term "preparation" as used below includes any cleaning, smoothing or similar operations that shall be required to ensure that the material to be painted attains a suitable condition.

To be ready for painting, a surface should be clean, dry and sound. The surface to be coated shall be free from any deleterious material liable to impair good paint adhesion or attack the coat.

For removing rust and mill scale on structural steel, piping and other steel surfaces, those parts suitable for sandblasting shall be sandblasted to a grade specified or required in accordance with SIS 05.59.00 (Sverige's Standardize rings Commission) or the American's SSPC-SP standard. This applies particularly to parts, which will be in contact with water, exposed to heavy condensation and humidity or subjected to high temperature.

For health reasons, sandblasting without quartz sand shall be carried out.

Sand blasting shall be such as to obtain a smooth surface free of foreign matters with a roughness of min. 0.04 mm. Corundum or an equivalent mineral shall be used and the grain size of the blasting medium shall not exceed 1.2 mm.

All parts of the Works shall be sandblasted at the shop unless otherwise specified or approved by the Engineer. The sandblasted surfaces shall receive a shop coat with a quick-drying highly pigmented 2-pack zinc-rich primer, unless otherwise specified.

Parts, which cannot be sandblasted, shall be cleaned of rust by power tool cleaning to the highest degree possible.

Hand or power tool cleaned parts of minor importance and not exposed to water or humidity may be coated with a quick-drying rustproof primer formulated on a combination of synthetic resins (ready-mixed paint).

Surface Preparation for priming:

Blast cleaning shall be carried out only when the following time and relative humidity schedule for application of the first coat can be achieved and maintained:

Sl. No.	Relative Humidity	Time
1	85% or above	Do not Blast
2	80-84	2 Hours
3	70-79	4 Hours
4	60-69	10 Hours
5	50-59	12 Hours
6	30-49	24 Hours
7	Under 30%	1 Week

Primer:

The primer serves, in the first place, as protection against corrosion. In addition, adherence between base, primer and finish paint is achieved. Primers have only a limited weather resistance. The specified dry film thickness shall be applied to all surfaces of the equipment as required. After the aforesaid has been done, the equipment or parts thereof may be stored in the open air for a limited time only until the finish coat is applied. Only 2-component epoxy resin zinc rich primer shall be used for priming on sandblasted surfaces.

4.10.6 Galvanization of Mandatory Items

Unless otherwise specified, all structural steel including ladders, platforms, handrails and the like and all exterior and interior steel surfaces of outdoor Works, as well as bolts and nuts associated with galvanized parts shall be hot-dip galvanized, electrolytically galvanized or sherardized, as may be appropriate to the particular case.

Galvanizing shall be performed in accordance with ASTM Specification A123/A123M-17 or equivalent standard

Material:

For galvanizing, only original blast furnace raw zinc shall be applied, which shall have a purity of 98.5%.

The thickness of the zinc coat shall be:

ii) For bolts and nuts, approx. 60 micrometer,

iii) For all other parts, except for hydraulic steel structures or parts intermittently or permanently submerged in water, approx. 70 micrometer,

iv) For hydraulic steel structures or parts intermittently or permanently submerged in water, approx. 140 micrometer, in accordance with "VDEW, Druckrohrleitungen -Association of German Electricity Utility Companies, Steel Penstocks".

Cleaning:

All material to be galvanized shall be cleaned carefully of rust, loose scale, dirt, oil, grease, and other foreign matters. Particular care shall be taken to clean slag from welded areas.

Galvanizing of plates and shapes:

Where pieces are of such lengths that they cannot be dipped in one operation, great care shall be exercised to prevent warping.

Finished compression members of steel structures shall not have lateral variations greater than one-thousandth of the axial length between the points, which are to be supported laterally. Finished tension members shall not have lateral variations exceeding 3 mm for each 1.50 m of length. Materials with sharp kinks or bends shall be rejected. All holes in material shall be free of excess spelter after galvanizing.

Galvanizing of hardware:

Bolts, nuts, washers, locknuts and similar hardware shall be galvanized in accordance with the relevant standards. Excess spelter shall be removed by centrifugal spinning.

Straightening after galvanizing:

All plates and shapes, which have been warped by the galvanizing process, shall be straightened by being re-rolled or pressed. The material shall not be hammered or otherwise straightened in a manner that will injure the protective coating. Materials that have been harmfully bent or warped in the process of fabrication or galvanizing shall be rejected.

Repair of galvanizing:

Material on which galvanizing has been damaged shall be re-dipped unless the damage is local and can be repaired by soldering or by applying a galvanizing repair compound; in this case, the compound shall be applied in accordance with the manufacturer's instructions.

Soldering shall be done with a soldering iron using 50/50% solder (tin and lead). Surplus flux or acid shall be washed off promptly and the work shall be performed so as not to damage the adjacent coating or the metal itself. Any member on which the galvanized coating becomes damaged after having been dipped twice shall be rejected.

4.10.7 Painting Works (External and Internal)

i) **Surface Preparation** (Primed, Galvanized or Stainless Steel Surfaces):

All surfaces to be painted shall be thoroughly cleaned by suitable means before application of paint. After cleaning the surfaces shall be rinsed in a manner that no residues will remain.

Primed surfaces contaminated with oil or grease shall be de-greased in a manner not affecting the quality of the primer. 2-component coatings older than six (6) months shall be roughened prior to the application of the next coat.

Hot-dip galvanized surfaces, which are to be painted, shall be lightly sandblasted prior to through cleaning.

ii) **Finishing Coats:**

Whenever specific colouring is required or where priming is not sufficient for protection against corrosion a finishing coat shall be applied. If not otherwise specified, finishing coats shall be applied to primed surfaces. The primed surface shall be prepared as specified above. Selection of finishing coats with regard to quality and quantity shall be governed by the ambient conditions and its effect on the painted surface.

The Engineer will select the type and shade of colouring in accordance with a standard colour code (e.g. VSLF, RAL, Munsell etc.). For this purpose the Contractor shall submit colour cards or colour samples. On request of the Engineer colour samples shall be applied to selected surfaces to be painted.

iii) **Painting Systems:**

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The specified painting systems including surface preparation and the permissible application methods are listed on the enclosed charts (Painting Systems) **Annexure-I.**

iv) **Colour Schedule:**

Colour standard references to major equipment / system shall be as mentioned in **Annexure-II**. The interior of all cubicle and panels shall preferably have a matt white finish unless specified otherwise.

v) **Cutting and Welding of Painted Structures:**

All painted structures to be cut by torch or blade for fitting and welding purposes and all field-welds shall be prepared.

Reason for this preparation work is the development of aggressive residue when the paint is burned. This residue cannot be removed and thus a proper surface preparation is not warranted.

Repair of the damaged surface protection shall be executed according to "Repair of Primer and Finish Coats" described below.

4.10.8 Repair of Primer and Finish Coats

i) **General:**

For touching up, the same paint shall be used as for the original painting work. Repaired finish coats shall be of identical appearance with the original and no difference in the colour shall occur.

ii) **Galvanized and Painted Structures:**

Repairs on galvanized and painted structures shall be carried out as follows:

i) Damages to painting and galvanization:

Surface Preparation: Scraping, wire brushing or grinding to Grade ST 3 according to SIS 055 900-1967.

Repair of Coatings: One coat of 2-component epoxy resin zinc-chromate primer. Dry film thickness minimum 0.050 mm.

Two coats of 2-component epoxy-resin micaceous iron oxide (mio) paint. Total film thickness min. 0.160 mm.

The colour of the paint shall be the same as originally applied.

ii) Damage to Painting only:

Surface Preparation: Thorough cleaning of the damaged surface i.e. removal of oil, grease, dust, etc.

Repair of Coatings: Two coats of 2-component epoxy-resin micaceous iron oxide (mio) paint. Total film thickness min. 0.160 mm. The colour of the paint shall be the same as originally applied.

iii) **Painted Structures:**

Repairs on painted structures shall be carried out as follows:

Surface Preparation: Scraping, wire brushing or grinding to Grade ST 3 according to SIS 055 900-1967.

Prime Coat: One coat of 2-component epoxy resin zinc-chromate primer. Dry film thickness minimum 0.050 mm.

Intermediate and finish Coats: Type, number of coats and dry film thickness, shall correspond to the specified "Painting Schedule" in Annex1.

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4.10.9 Quality Control

The minimum dry-film thickness prescribed in these Specifications shall be observed. Of each 100 m2, one area of 10 m2 will be measured for dry-film thickness. No measured thickness shall be less than the specified thickness. Where the minimum thickness is not achieved, the coat shall be repaired to reach the specified minimum dry-film thickness.

Spot & random checking shall be carried out by Owner and the contractor shall offer for inspection accordingly.

The dry-film thickness shall be measured by approved gauges; the cost of two new electronic gauges shall be included in the Contract for use of the Engineer.

For checks on porosity, the Contractor shall furnish a D.C. variable high tension test instrument with built-in pore counter. The test voltage shall not exceed 2000 V. The tests shall not be performed within 0.5 m distance from uncovered, corrosion resistance surfaces.

The instruments purchased for quality control shall be handed over to Employer after commissioning of the Project without payment to the Contractor.

Upon completion of each coat, the painter shall make a detailed inspection of the painting finish and shall remove from adjoining work all spattering of paint material. He shall make good all damage that can be caused by such cleaning operations.

A detailed inspection of all painting work shall likewise be made, and all abraded, stained, or otherwise disfigured portions shall be touched up satisfactorily or refinished as required to produce a first-class job throughout and to leave the entire work in a clean and acceptable condition.

4.10.10 Painting Materials

The Bidder shall provide a complete, reliable coating system. Coating materials shall be standard products of a paint manufacturer with proven experience in the field of corrosion protection of the type of works to be supplied.

The Bidder shall submit for the Employer approval full details of the preparation, type of materials, methods and sequences he proposes to use to comply with the requirements for the protection of the Works.

Painting of the repainted surface shall be in accordance to the relevant standard and shall be detailed by the Bidder for Engineer in-Charge’s acceptance.

4.10.11 Painting Guarantee

The guarantee period for all painting shall be three (3) years, starting from the issue of the "Test on Completion Certificate". This painting guarantee period shall be effective regardless of any other guarantee periods for the project or parts of the project, or any "Defects Liability Certificate", issued prior to the elapse of the painting guarantee period.

At the end of the painting guarantee period the anti-corrosive protection of the painted or galvanized surfaces shall not have a degree of rusting higher than RE 1 (one) on the European scale of degree of rusting for anti-corrosive paints, (the corrosion committee of the Royal Swedish Academy of Engineering Sciences, Stockholm).

4.11 Metal Work

4.11.1 Embedded Metal Work

The bidder shall supply & install all anchors, fasteners, embedded metal work, piping, & sleeves associated with & required for the equipment to be installed under this contract, except if otherwise mentioned in the specifications.

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As far as practicable, the supports shall be of consistent design throughout. Attachments to concrete shall wherever practicable be by means of embedded inserts.

The Bidder shall be responsible for the determination and details of all loads and forces exerted by his equipment and transferred to the foundation.

The Bidder shall show the location and full details of all embedded components on his drawings and shall be responsible for the completeness and accuracy of his drawings and the information supplied to others.

Any steel work which is to be built into the concrete foundations shall not be painted or coated unless otherwise approved or specified.

4.11.2 Miscellaneous Metal Work

Except where otherwise indicated elsewhere in the Particular Technical Specifications, the Bidder shall fabricate and supply the following:

i) All platforms, walkway, staircases/ladder, guard, handrails etc. shall be provided for convenient and safe access to all operating equipment and points of lubrication. Also chequered plate/grating covers shall be provided for MIV removal hatch, Runner removal hatch, equipment handling hatches and openings/trenches for cables, cable trays, pipes, ducts or any other trench/opening required for completing the floors around and over the works supplied under the contract. The use of ladders shall be kept to a practicable minimum. Where ladders are approved for use they shall be of steel with anti-skid and safety latch, have an inclination of 70^0 to the horizontal and a minimum width of 450 mm.

ii) The material for all handrails shall be stainless steel. Handrails shall be of tubular steel construction, except that the top rail shall be of flat, fitted with a formed plastic covering. Gratings for hatches, platform, walkways, staircases etc. shall be factory made, fabricated mild steel electro forged type conforming to relevant standard. The electro-forged grating shall be confirming to BS: 4592 for welded pattern and permissible deflection due to uniformly distributed load. Appropriate structural support for gratings on both sides of span should be provided for maximum feasible length. Grating shall be hot dip galvanized confirming to IS: 2629 and mass coating as per IS: 4759.

iii) The grating shall be of approved make. The design of grating and chequered plate covers shall be based on the loading in the area/floor in which the grating is provided as per IS-4247 and shall be subject to approval by employer. The minimum thickness of chequered plate and grating plate/bar shall be 8mm and 5mm respectively.

iv) Safety guards at each point where normal access provision would permit personnel to come with reach of any moving equipment to be provided under the Contract.

v) Covers and Curbing for dismantling hatches in main floors will be provided by the civil bidder.

5 Mechanical Works and Steel Structures

5.1 General

All mechanical Works and steel structures of any mechanical or electrical installation shall comply with this General Technical Specification and the requirements of the Particular Technical Specification.

The Works shall be of an approved, reliable design providing the highest possible degree of uniformity and interchangeability.

All Works shall be pre-assembled in the manufacturer's premises to an utmost extent.

Revolving parts shall be truly balanced both statically and dynamically that when running at normal speed and at any load up to the maximum, there will be no vibration due to lack of such balance.

Structural materials may be straightened by methods which will not result in injury, sharp kinks or bends which shall be cause for rejection. Finished members shall be free from kinks or bends. Shearing shall be done accurately and all portion of the work neatly finished. Corners shall be square and true unless otherwise shown on the plans.

Re-entrant cuts shall be made in a workmanlike manner. Where they cannot be made by shearing, a rectangular punch may be used. Re-entrant cuts shall be filleted, unless otherwise approved by purchaser.

Bends, except for minor details, shall be made by approved dies or bending tools. When heating is required for the satisfactory working of the metal, it shall be allowed to cool under conditions that will not destroy the original properties.

Steel with welds other than those definitely indicated on the shop drawings, or specified or otherwise card for, will not be acceptable. All bolts, nuts, and screws shall be adequately tight.

5.2 Materials

Materials shall be new and of high-grade quality, suitable for the purpose, free from defects and imperfections, and of the classifications and grade meeting specification requirement and shall be subjected to acceptance by the Employer. Material specifications, including grade or class shall be shown on the appropriate Bidder's detail drawings submitted for review.

All materials or parts used in the equipment shall be tested in conformity with the standards accepted by the Employer.

Certified Material Test Report for the materials of major/important components and/or materials for special application shall be furnished to the Employer as soon as possible after the tests are performed. Each test certificate shall identify the components for which the materials are used and shall contain all information necessary to verify compliance with the contract.

5.3 Bolts, Screws, Nuts, etc.

All bolts, studs, screws, nuts, and washers shall be to the ISO standard (metric system) except other standards will be considered for specific applications. The extent to which other standards are proposed shall be indicated by the Bidder.

Where mild steel bolts and nuts are used, they shall be of the precision cold forged washer faced type if commercially available in the size required. Alternatively, approved hot forged bolts and nuts, machined so that the undersides of bolt head and nut are faced and parallel to one another when assembled, may be used. In the latter case, a suitable fillet shall be machined between the bolt head and shank. All parts, other than structural steel work, bolted together, shall be spot faced on the back to ensure that nuts and bolt heads bed down satisfactorily. Bolts machined from bar stock shall not be used without approval of the Employer. All bolting material shall be adequately treated against corrosion before dispatch from the workshop. Mild steel nuts and bolts shall be zinc or cadmium plated. Stainless steel bolts, nuts washers and screws shall be used in water or when exposed to high humidity, for holding renewable parts and parts made of stainless steel.

All bolts or studs which will be subject to high stress and/or temperature shall be of approved high tensile material with nuts of approved material. All bolts and studs larger than 60 mm in diameter, which are not accessible for tightening, and un-

tightening by commercially available pneumatic impact wrenches shall be drilled for heaters or shall have an extension for pre-tensioning by hydraulic tools.

Washers shall be provided under bolt heads and nuts unless otherwise approved by the Engineer in-Charge. All ferrous nuts and bolts on Works items where dismantling may be required during the life of the Works shall have their threads coated with an approved anti-seize compound. When in position, all bolts or studs shall project through the corresponding nuts by at least one thread, but this projection shall not exceed three threads, unless more length is required for adjustment. All nuts and set screws shall be securely fastened, to prevent loosening due to vibrations, using spring washers, lock nuts, split pins, self-locking inserts or 'Loctite' as appropriate for the purpose and material used.

The Bidder shall supply the net quantities plus 5 percent of all permanent bolts, screws and other similar items and materials required for installation at the Site. Any such rivets, bolts, screws, etc., which are surplus after the installation of the Works has been completed shall become spare parts and shall be wrapped, marked and handed over to the Employer.

5.4 Seals

The material for large gate seals shall be of first quality non-ageing rubber material, which shall be unaffected by wetting and drying or temperature changes. The degree of hardness according to Shore shall be 50-55 for sill sealing and 60-80 for lateral sealing. In case the Contractor intends to supply synthetic rubber material, with or without fluoro-carbon cladding, he shall furnish the name of the manufacturer and technical data of the material for the Engineer's approval. All seals shall be suitable for ambient temperature conditions of (-) 20 deg. C.

Rubber Seals:

Seals shall be designed and mounted in such a manner that they are adjustable, water tight and shall be readily removed and replaced.

Seals shall be moulded. Extruded seals will not be permitted. Where seals are installed curved, they shall be clamped in a jig, which shall form them to the proper radius before the holes are laid out and drilled, and the ends trimmed. Holes in related parts of the seal assemblies shall be carefully drilled, using a template, and assure proper matching when the seal units are assembled. Arrangements shall be made to provide effective continuity of sealing at the corners.

All adjusting screws and bolts for securing the seals and seal assembly in place shall be of stainless steel.

Seals shall be made of synthetic rubber suitable for the temperature ranges of equipment and conditions at the Site and shall be of a material that has proven successful in similar applications. Joints shall be watertight and seal materials shall have following physical properties as determined by tests made in accordance with the relevant Standards.

Sl. No.	Property	Limits
1	Tensile strength	21.0 MPa minimum
2	Ultimate elongation	450% minimum
3	Durometer hardness (Shore, Type A)	60 – 70
4	Specific gravity	1.1
5	Water absorption (70° C for 48 hours)	5% by weight (max.)
6	Compression set	30% maximum
7	Tensile strength after oxygen bomb ageing (48 hours at 70° C)	80% (min.) of tensile strength

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5.5 Corrosion Resistant Bolts and Nuts

Corrosion resistant steel or bronze shall be used for bolts and nuts when either or both are subjected to frequent adjustment or frequent removal, such as adjusting bolts for packing glands on removable screens or strainers, on adjustable bearings, rubber seal holders, etc. Bolts on manholes shall be of high-strength stainless steel. Protective measures against electrolyte corrosion shall be foreseen where necessary.

5.6 Drives and Gears

Gears shall be designed so that all stresses are within allowable limits when the maximum loads are being handled. On request of the Engineer in-Charge, the manufacturer shall submit the calculation of the gears.

Where practicable gear wheels shall be forced fit on the shaft and in addition, shall be keyed adequately to prevent any relative motion between the wheel and shaft. Couplings and collars shall be the shrouded or protected-type, free from projections of any kind. All bearings shall be mounted in dust-proof housings. Base of bearing supports shall be machined and shall rest on machined surfaces.

5.7 Lubrication, Lubricants, Fuel

Efficient means of lubrication, suitable for use under Site conditions, shall be provided for all moving parts.

The contamination of the air, water and soil by lubricants and fuel shall by all means be avoided by applying of an appropriate design and layout of the Works in conformity with the latest recognized standards for modern engineering practice.

The number of different lubricants, transformer oils, oils for pressure systems, etc., used in the items of Works throughout the Works shall be limited to a minimum in order to facilitate keeping stocks and maintenance.

The Employer reserves the right to request the use of certain types of lubricants, oils, etc. The Bidder shall not be entitled to claim extra payment for this request. All different types of oils, lubricants, etc., shall be subject to the written approval of the Employer.

Unless otherwise stated in the Particular Technical Specifications, the first oil or grease filling for bearings, pressure oil systems, transformers, etc., including the necessary quantity for flushing and for the first oil change shall be included in the Tender Price.

5.8 Piping, Fittings, Valves, Gates and Heat Exchangers

5.8.1 General

Unless otherwise stated, all piping fitting, valves shall be designed for at least 1.5 times of the working pressure but minimum for "nominal pressure" PN 16 and tested with 1.5 times of the design/nominal pressure. All required piping shall be furnished complete with flanges, joints, expansion joints, gaskets, packing, valves, drains, vents, pipe suspensions, supports, etc.

Welding as well as application of corrosion protection coats shall be done in the manufacturer’s shop as far as possible.

All flanges of pipes and associated piping equipment shall have common standard flange drilitions standards.

5.8.2 Valves, Gates

Small valves and gates shall conform to relevant IS, “Conditions and Terms for Delivery of Valves,”

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Generally, valves shall be leak-proof in either flow direction (except for non-return valves) when the design pressure is applied.

All valves with design pressures higher than PN 16 and diameters larger than DN 100 shall be workshop-tested to relevant IS for tightness and soundness of materials.

The change of the disc seals of butterfly valves shall be possible without dismantling of disc and body.

Valves shall close clockwise and be provided with position indicators and padlock kit. The drive units of motor-driven valves shall also be provided with hand wheels for manual operation. The hand wheel shall be operable under all conditions and shall be independent of the motor drive. Further, it shall not be rigidly coupled to the motor drive and shall not compulsorily turn when the motor is energized.

To facilitate operation, large valves and gates shall be provided with by-pass lines for pressure balancing, if required.

All valves shall be readily accessible for both operation and maintenance, and where necessary for ease of operation the spindles shall be extended and an approved form of pedestal hand-wheel provided at convenient operating floor level.

Shut-off valves shall be suitable for opening and closing against full unbalanced pressure, including closure against free discharge. If necessary, bypasses are to be provided to meet these requirements.

Valves spindles and pins shall be of stainless steel, spindle nuts and bushes of bronze, the body at least of improved C.I (e.g. Mechanite).

All pressure reduction valves: safety valves and similar components shall be workshop-tested and provided with a work certificated 2.3 to DIN 50049.

Material of valve body and other parts shall be as mentioned below for all type of valves:

Sl. No.	Part Name	Valve Size	Application	Material/ Standard/ Grade
1	Valve body	DN 50 and below	Water	Stainless steel (ASTM A276Type316/ ASTM A182Gr.F316 or better)
2	Valve body	Above DN 50	Water	Forged steel (ASTMA216Gr. WCB/ ASTMA105 or better)
3	Valve body	All	Air & oil	Stainless steel (ASTM A276Type316 or better)
4	Valve spindle/ shaft & pins	All	Water, air & oil	Stainless steel (AISI410 or better)
5	Disc/ ball/ Wedge	All	Water, air & oil	Stainless steel (ASTM A 351Gr.CF8 or better)
6	Gland seal/ seat	All	Air & oil	PTFE
7	Seat/ body lining	DN200 and above	Water	PTFE
		Below DN 200	Water	PTFE/ EPDM (Peroxide cured)

Unless otherwise specified in Particular Technical Specification, valve type used in water, oil and air application shall be as per below:

Water Application:

i) All the valves connected to penstock (such as penstock/spiral case drain valve or any valve for cooling water or fire-fighting system tapping) shall be heavy duty forged gate type. The same shall be capable of open under 100% unbalance condition.

ii) Penstock drain valve, fire-fighting system tapping and other tapings from penstock shall also have guard valves.

iii) All valves connected to tail race and draft tube shall be heavy duty gate valves.

iv) All valves for flow regulation shall preferably be heavy duty globe type.

v) All valves which are to be frequently opened and closed shall be heavy duty gate valves.

vi) All valves used in ejector system, fire-fighting system shall necessarily be heavy duty gate valves.

Generally, all valves upto DN80 shall be heavy duty gate valves (except in flow regulation).

Oil Application:

i) Generally, all valves shall be heavy duty ball/ gate/ needle/ globe type made of stainless steel.

ii) All valves for flow regulation shall preferably be heavy duty globe type.

Air Application:

i) All valves shall be heavy duty ball type made of stainless steel.

ii) Use of Gate valves shall be avoided and if need be, the same should only be used in water outlet circuit, where pressure is less. All Gate valves shall preferably be Resilient Seated and no part of valve body or stem shall expose to media. Heavy duty gear operator units with hand wheel shall be provided for Gate valves size DN200 and above. Gate valves shall comprise of following:

- Heavy duty non corrosive bronze/acetal copolymer bushing,
- Heavy duty sealing with self-adjusting double U- cup seal for positive sealing in both directions,
- Machined and hand polished disc edges,
- Valve body lining shall preferably be integrally moulded and bonded.

iii) All pressure reduction valves; safety valves and similar components shall be workshop-tested and provided with a work certificate 2.3 to DIN 50049.

5.8.3 Piping and Fittings

All required piping shall be furnished complete with flanges, joints, expansion joints, gaskets, packing, valves, drains, vents, pipe suspensions, supports, etc.

All piping and cooling water pipes shall be heavy duty stainless steel conforming to ASTM 304

Pipe connections embedded in concrete shall be welded. Other pipe connections shall be flanged. The flange material shall be in conformance with the pipe material. The Contractor shall select the location of the weldments as to ensure sufficient access for adequate touch-up treatment for corrosion protection.

Stress calculations of steel pipes shall be in accordance with DIN 2413, “Steel Pipes under Internal Pressure” or with “AD-Merkblätter; German association of Manufacturers of Pressure Vessels, Memos.” In no case, the superimposed stress of bending, tension, compression, etc., calculated to the shape variation hypothesis, shall exceed 0.7 of the yield point at maximum applied load at any point of the piping.

The maximum applied load shall take into account test pressure, water hammer pressure waves, thermal forces, dead weight, etc. On request of the Engineer, a

calculation on pipe stresses has to be submitted by the Contractor at no extra cost. The requested calculations will be subject to the Engineer's approval.

The minimum steel pipe wall thickness shall be the "normal" or "standard" wall thickness as stated in the applicable standards.

Metric flanges shall be used throughout. Welded flanges shall be weld-neck or slip-on flanges. The raised face shall be machined. Joints between stainless and normal steel flanges shall be of the insulated type.

If the piping crosses over joints of civil structures of different settlement, the piping shall be provided with flexible joints to allow for vertical, horizontal, and angular deviations.

Piping installation shall be sloped to prevent trapping of air bubbles. Where required suitable venting system shall be provided.

Adequate clearance shall be given to parallel pipes to allow for easy maintenance without disturbing other lines. All overhead piping shall have a minimum clearance of 2.00 m from operating floors and platforms.

Where required water piping shall be provided with anti-condensation insulation with vapour proof cover.

Bends and flanged shall preferably be of the forged type below DN 200. Mitered/Fabricated bends and flanges shall be allowed for larger sizes subject to the Engineer's approval.

All piping shall be acid-treated to guarantee clean surfaces, completely free from welding residues. This treatment shall be applied to workshop and site manufactured piping. The entire piping arrangement shall be subjected to the pressure test in section at the site.

Oil pipes shall generally not be embedded in concrete. Oil pipes crossing civil structures shall be routed through sleeves embedded in the concrete. All oil piping shall be hydrostatically tested at a pressure 100 % greater than the maximum working pressure. As far as possible, oil pipes shall be prefabricated in the Bidder's workshop. They shall be welded except at terminal points and as necessary for erection and future dismantling.

5.8.4 Oil Piping

All oil piping shall be Stainless steel material unless especially mentioned in the respective PTS. Oil pipes shall be as far as possible prefabricated in the Contractor' workshop. They shall be welded except at the terminal points and as necessary for erection and future dismantling. The contractor shall select the location of the weldments as to ensure sufficient access for adequate touch-up treatment for corrosion protection. Pipe connections larger than 50 mm in diameter shall be provided with steel-flanged connections.

All piping shall be hydrostatically tested at a pressure 50% greater than the maximum working pressure (design pressure). The entire pipe arrangement shall be subjected to the pressure test after complete assembly at the site.

Oil pipes shall not be embedded in the concrete. Oil pipes crossing civil structures shall be routed through sleeves embedded in the concrete.

All oil piping shall be acid-treated to guarantee clean surfaces, completely free from welding residues. This treatment shall be applied to workshop and site manufactured piping respectively.

The piping can either treated in an acid-bath or being completely filled with acid. The duration of the treatment shall be approx. 6 hours. After that the piping shall be neutralized flushed and corrosion protected for final installation.

5.8.5 Pipe Supports and Hangers

All pipe work and accessories shall be mounted and supported in a safe and neat manner.

All brackets, stays, frames, hangers and supports for carrying and staying the pipes, including their fasteners shall be included in the supply and completed by the Bidder at the Site. Pipes and fittings shall be supported at or near flanges wherever possible.

Supports and hangers shall be designed and arranged so that any pipe can be withdrawn without disturbing the others.

All heavy valves and other mountings shall be supported independently of the pipes to which they connect to the satisfaction of the Employer.

The Bidder shall supply drawings showing the location of each major anchor and support and the weight to be carried by that support.

5.8.6 Heat Exchangers

Unless otherwise stated, all the heat exchangers shall be designed for a nominal pressure PN 10. All piping shall be tested with 1.5 times the design/nominal pressure. Specification of the material of the heat exchanger shall be:

Sl. No.	Description	Tubular Type	Plate Type
1	Material for Cooling tube/plate	Cupro-nickel (90:10)	Stainless Steel (304/316L or better)
2	Thickness of cooling tube/plate	Generating unit :1.0mm or more. Other: 0.5mm or more	0.6mm or more
3	Frame/body	stainless steel	stainless steel

5.9 Mechanical Instruments

All mechanical parts of instruments shall be suitably protected against shocks and vibrations, heat, humidity and splash water, etc.

Pressures gauges shall be provided with a damping liquid, e.g., glycerin, to compensate vibrations. Pressure gauges without damping means are not permitted, unless approved by the Engineer.

5.10 Pressure Oil Systems

Pressure tanks (Piston/Bladder type accumulator) shall be designed, fabricated and tested in accordance with approved standards. The appropriate inspection certificates shall be furnished.

Oil sump tanks shall be provided with:

i) Suitable access openings,
ii) Fine mesh strainer combined with a magnetic filter through which all oil returning from the servomotors shall pass. The strainer shall be readily removable for cleaning,
iii) Dehumidifying air filter,
iv) Flush-mounted oil-level indicator,
v) Filling connection with a suitable strainer,
vi) Drain connection with hand operated shut-off valve.

Sump tanks shall be installed so that the bottom of the tank and the drain connection are at least 40 cm above the floor. The bottom of the tank shall be inclined in the direction of the drainage. The pumps shall be removable without the necessity of emptying the tank.

Servomotors shall be provided with suitable connections for pressure gauges on the pressure and suction sides of the piston. Servomotor piston rods shall be of stainless steel provided with a hard chromium layer of approximately 0.04 mm thickness. A suitable protection for the piston rod seal shall be provided.

5.11 Compressed Air Systems

The provisions for safety of the entire compressed air system shall conform to internationally accepted standards. The standards proposed by the Contractor will in any case be subject to approval of the Engineer-in-charge.

Vessels shall be of the cylindrical, vertical type and shall be mounted on a structural steel base. The inner surfaces of the vessels shall be protected with an appropriate paint coating or the vessels shall be hot dip galvanized. Each vessel shall be equipped with the following devices:

i) inlet sockets with valves,
ii) outlet sockets with valves,
iii) 2 pressure safety valves,
iv) 2 dial pressure gauges, one of the gauges with 4 electrical contacts,
v) 1 manhole or inspection hole,
vi) 1 drain valve.

In case the pressure vessel is used for pressurized oil or water systems, the vessel shall further be equipped with:

i) 1 transparent level gauge with shut-off valves at both ends,
ii) Level indicators with electrical contacts in a number as required or specified.

Compressors shall be provided with:

i) Automatic lubrication,
ii) Air-intake filter and silencer,
iii) Thermometer for measuring temperature of the compressed air,
iv) Automatic shut-down if the discharge air temperature exceeds a predetermined, adjustable value,
v) Discharging valves,
vi) Water drain valves,
vii) Water/oil separator,
viii) Pressure safety valve,
ix) Compressed air cooler,
x) Non-return valve,
xi) Inlet pressure valve,
xii) Outlet pressure valve,
xiii) Automatic moisture trap.

The water/oil separator shall be equipped with an automatic solenoid-operated drain valve to achieve automatic draining during standstill. The compressor stages shall be equipped with discharge valves, which shall close time delayed after start to avoid compressor start against full pressure.

The compressors shall be delivered as package units on common frame with the appropriately sized AC squirrel cage motor and the respective motor starter panels, ready for operation.

Each vessel shall pass a pressure test at 1.5 x maximum working pressure for 8 hours in the manufacturer's workshop before coating is applied.

If requested by the Engineer, each compressor shall pass a performance test in the manufacturer's workshop to a standard mutually agreed upon, e.g., DIN 1945, VDMA 4362, without extra cost. The readily assembled compressors, controls, and switchgear shall be subjected to functional tests.

Each vessel shall be furnished with a test certificate of an independent, reputable underwriters' society.

5.12 Pumps

Materials of the Impeller, Shaft, Keys and Sleeves of the pumps shall be stainless steel and wear rings shall be bronze. The pump casing for horizontal centrifugal and submersible pumps shall be cast steel and ductile/ improved cast iron respectively.

The impeller diameters shall be neither maximum nor minimum impeller size for the selected pump size. The pumps shall withstand corrosion and wear by abrasive matters within reasonable limits. Each pump shall be equipped with mechanical seals to ensure zero water leakage under normal operating conditions. However, suitable drainage facilities shall be provided as a precaution in case any leakage occurs during operation.

Each pump shall be fitted with:

i) Check valve at the discharge side,

ii) Air and drain valve,

iii) Pressure gauge & pressure / flow switch,

The size of the pump motor shall be at least 15% higher than the maximum power required by the pump at any operation point.

For dirty water pumps, the water passages of corrosive material shall be rubber-lined.

For non-submersible type, pumps and motors shall be mounted on common frames, while in case of submersible type, the same shall be contained in the common casing and designed as a package unit with incorporated suction strainer and check-valve.

The motors of submersible pumps operating in potable water shall not be filled with oil or other media detrimental to potable water. Motors of submersible pumps operating in dirty water may be filled with oil.

Dirty water submersible sump pumps with the motors mounted on top of the pump shall be suitable for running dry continuously, without damage to seals, bearing, or motors.

For any pump, the overall pump motor efficiency for the specified rated head and discharge shall not be less than 60% and maximum rated speed for pumps as 1500rpm.

If requested by the Engineer for pumps of a capacity higher than 30 kW, one in three pumps shall pass a performance test to HIS 14.6 grade 1E, with measurements taken at 0%, 50%, 80%, 100% and 120% of specified discharge at rated speed. The results have to be certified in a workshop certificate 2.3 to DIN 50049. For pumps of capacity higher than 100 kW, the shop tests shall be compulsory; test certificate 3.1 B in accordance with DIN 50049.

Prior to the test, the manufacturer shall provide certified motor performance curves.

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5.13 Lifting Equipment

5.13.1 Design and Calculation Standards

Generally, for design, stress calculation, manufacture and installation, the following standards and codes, besides other relevant standards and regulations, shall be applicable:

IS: 800, IS: 807, IS: 8177

DIN 4'100	Welded Steel Structures, Calculation and Design
DIN 4'114	Steel Structures: Stability (pp. 1 and 2)
DIN 15'018	Cranes, Steel Structures, Calculation and Design
DIN 15'020	Rope Drives Safety devices for the operating personnel
CMAA	Crane Manufacturer's Association of America

Safety devices for the operating personnel shall be provided wherever it is deemed necessary.

In addition, the safety rules outlined in VBG 8 of the German "Verband der Berufsgenossenschaft" or similar internationally recognized codes shall be observed. All safety rules, regulations and precautions shall be followed as per Indian Standards, Acts, Rules, etc.

Unless otherwise specified, the lifting equipment shall be classified to DIN 15020 as follows:

For lifting capacity up to 100 kN (10 tons) "class 2 m", representing an average daily working time of 2 to 4 hours and an equal share of small, medium, and heavy loads (normal duty);

For lifting capacity above 100 kN (10 tons) "class 1 Am", representing an average daily working time of 2 to 4 hours and a small share of heavy load lifts (light duty).

The Contractor shall state the various load combinations and factors of safety taken as a basis for calculation of the different components of the crane. In addition, the various factors of safety for the different load combinations shall be stated.

Each lifting equipment such as cranes or elevators shall be subject to a test operation with an overload = 1.25 x nominal load.

The crane girders and rails shall be calculated for a deflection not exceeding 1/1000 of the span at maximum nominal load.

Steel structures of lifting equipment shall be of welded construction, which can be assembled at Site. All field connections and joints shall be bolted.

For maintenance, inspection and lubrication, appropriate ladders, platforms and steps shall be provided, fitted with anti-slip chequered plates, tabular handrails and skirting. Walkways, stairs and platforms for lifting equipment shall generally be designed for a service load of 3000 N/m2.

For hand operation a handle shall be provided to allow operation under the disconnecting condition from electrical system and the operation force on the handle shall be less than 100 N per man, at the handle diameter of 600 mm which shall be located within 600 to 800 mm in height from the base.

5.13.2 Material Standards

The material to be used for manufacturing lifting equipment steel structures shall conform to DIN EN 10'025 or to the equivalent ASTM standards. However, the Contractor shall restrict the structural steel to FE 360 B and FE 510 C or ASTM A

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36; the latter may be regarded as equivalent to FE 430 C. For these structural steels, connecting bolts and welds, the allowable stresses given in DIN 15'018 shall apply.

If the Contractor intends to supply material other than that mentioned above, he can do so, provided their equivalence to the specified material standards is verified by the Contractor and approved by the Engineer.

The stresses between the track rails, their fixing elements and the concrete shall not exceed the following values:

Mean allowable compressive stresses	: 6 MPa
Allowable compressive stresses on edges	: 10 MPa
Allowable bond stresses	: 0.6 MPa

The stresses induced by maximum torque shall not exceed 80% of the material yield point.

5.13.3 General Design Particulars

Nameplates stating the nominal capacity in tons shall be attached to both sides of the lifting equipment structure and to both sides of the tackle. The printing shall be clearly legible from the floor.

Hoists, ropes, drums, sheaves and related Works shall be calculated to DIN 15'020 or equivalent standards.

Flexible couplings shall be installed to relieve the bearings and shafts from any stresses due to misalignment and to facilitate the removal of motors, wheels and gears. The motor couplings also shall be of the flexible type.

All couplings drive wheels and gears shall be press fit and keyed to the shaft.

All wheels shall have a hardened tread with a minimum Brinell hardness number of 400 and shall be made of carbon steel or low-alloy steel forgings. They shall have double flanges, shall be machined to a uniform diameter concentric with the hub bore.

All bearings shall preferably be anti-friction bearings designed to permit easy shaft disassembly and easy replacement. The minimum average lifetime under design load conditions shall be 5000 hours.

All sleeve bearings except those for the hooks and rope sheaves shall be lubricated by central lubrication systems. An independent system for the trolley and one or two independent systems for the bridge will be acceptable. These central lubrication systems shall satisfy the following requirements:

i) The lubricant quantity for each bearing shall be variable,

ii) Lubricant filters shall be installed in every lubricating pipe,

iii) The lubrication piping shall be arranged to be easily accessible for maintenance.

Gears shall preferably be designed as bevel gears. For all high-speed gears and pinions, oil bath lubrication shall be provided. Low-speed gears may be lubricated with soft grease. Suitable oil and grease drip pans shall be installed and be readily accessible for draining and cleaning.

Bridge and trolley drives shall be equipped with a spring-set, electrically (solenoid or electro-hydraulic) released shoe or disc brake, with capacities of at least 1.5 times the full operating torque of the drive.

The brake shall be applied when the motor control switch or the main switch is in the "off" position and/or in case of power failure in any phase.

The braking action shall be gradual and the brake shall become fully effective after a certain time lag.

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5.14 Steel Structures

Generally, design and stress calculation shall conform to:

i) DIN 1'050 Steel Structures, Construction,

ii) DIN 4'100 Welded Steel Structures, Calculation and Design,

iii) DIN 4'114 Stress Calculation of Steel Structures, stability,

iv) DIN 18'800 Steel Structures, Calculation and Construction.

For standards applicable to steel structures of lifting equipment, refer to "Lifting Equipment". The permissible design stresses for materials, bolts, rivets, etc. are given in DIN 18'800.

Adequate clearance of at least 2 m shall be provided at overhead steel structures to allow unobstructed passage.

Stairs and ladders shall have an inclination of approximately 30 degrees and 75 degrees respectively. Stairs shall be complete with handrails, min. 90 cm high, and kickboards of 8 cm height.

Vertical ladders shall be installed alternating left hand/right hand side to horizontal platforms placed approx. every 10 m of vertical height. Vertical ladders of more than 2.5 m height shall be guarded. Load assumptions for ordinary platforms shall be:

i) For platforms used by personnel and for support of light equipment with single weights of less than 1000 N and 2500 N/m2,

ii) For all other platforms 5000 N/m2.

Unless otherwise specified or stipulated in the applicable standards.

i) Platforms and stairs shall be provided with anti-slip checker plates,

ii) The materials used for general steel structures shall conform to mild steel FE 360 B and FE 510 C or ASTM A 36.

6 Electrical Works

6.1 General

The electrical items of Works of any electrical or mechanical installation to be provided under this Contract according to the Particular Technical Specifications shall - if not stated otherwise therein-fulfil the requirements of this Section.

All components shall be of an approved and reliable design. The highest extent of uniformity and interchangeability shall be reached. The design shall facilitate maintenance and repair of the components.

The Works shall be pre-assembled to the highest possible extent in the Bidder or Sub-Bidder's workshop, complete with all devices and wired up to common terminal blocks.

The power supply and control cables shall be laid up to these common terminal blocks. The required control and protection devices, instruments, etc., within the different scopes of work shall be supplied and connected by the relevant Bidder.

Unless otherwise agreed, ratings of main electrical Works (in-feeds, bus- ties) as selected or proposed by the Bidder, whether originally specified or not, shall generally include a safety margin of 10% under consideration of the worst case to be met in service. Prior to approval of such basic characteristics, the Bidder shall submit all relevant information such as consumer lists, short circuit calculations, de-rating factors, etc.

Short-circuit calculations shall be evaluated giving full evidence that every electrical component can withstand the maximum stresses under fault conditions, for fault levels and durations obtained under the worst conditions, e.g., upon failure of the corresponding main protection device and time delayed fault clearing by the back-up protection device.

All Works shall be suitable for the prevailing climatic conditions.

Outdoor installations needing protections shall be protected against solar radiation by means of adequate covers, where required.

The Bidder shall ensure that all the supplied Works is insensitive to any signals emitted by wireless communication equipment.

6.2 Standards

The design, manufacture and testing of all Works and installations shall strictly comply with the latest edition of the relevant IEC publications.

6.3 Colour Code

In general, the colour code for electrical Works shall be as described in Annexure-II.

The manufacturer's painting systems shall be used to the maximum possible extent but shall by all means be subject to the approval of the Employer. Final coats of paint shall be matching adjacent installations, where required.

6.4 Electric Motors

6.4.1 General

All motors shall be of approved manufacture and shall comply with the requirements of this Chapter. Motors of the same type and size shall be fully interchangeable and shall comply - as far as applicable - to IEC standard motor dimensions.

The general construction shall be stiff and rigid; no light metal alloy casings will be accepted. All precautions shall be taken to avoid any type of corrosion.

All motors shall be fitted with approved types of lifting hooks or eyebolts as suitable.

AC motors shall have squirrel cage type rotors.

6.4.2 Motor Voltages and Power Ratings

The service voltages and corresponding power ratings for electric motors to be used in the Project shall be as follows:

i) **Motors up to 100kW**

Service Voltage	A.C 415/240 V, 50 Hz
Mode of starting	Direct-on-line up to 50kW above 50kW with suitable starters

ii) **Motors up to 0.75kW**

Service Voltage	A.C 415/240 V, 50 Hz
Mode of starting	Direct-on-line up to 50kW above 50kW with suitable starters

iii) **Motors intended to work on the D.C. system**

Service Voltage	220V D.C
Mode of starting	Resistor

6.4.3 Rating

The rating of the motors shall be adequate to meet the requirements of its associated equipment. The service factor, being the ratio of the installed motor output to the required power at the shaft of the driven machine at its expected maximum power demand, shall be applied as follows:

Sl. No	Power Demand of Driven Machine	Service Factor
1	Upto 5kW	1.2
2	More than 5kW	1.1

A.C. motors shall be capable of operating continuously under rated output conditions at any frequency between 95% and 105% of the rated frequency and/or with any voltage variation between 90% and 110% of the nominal voltage. A transient over voltage of 130% of the nominal voltage shall as well be sustained.

Further, the motors shall be capable of maintaining stable operation when running at 70% nominal voltage for a period of 10 seconds. The pullout torque for continuously loaded motors shall be at least 160% of the rated torque and for intermittently loaded motors 200% of the rated torque.

D.C. motors shall be capable of operating continuously under rated output conditions at any voltage between 90% and 110% of the nominal voltage with a fixed brush setting for all loads. Unless otherwise approved, the speed drop between no-load and full-load shall not exceed 10% of no- load speed.

6.4.4 Starting

A.C. motors shall be designed for direct on-line starting. They shall be capable of being switched on without damage to an infinite busbar at 110% of the nominal voltage with an inherent residual voltage of 100% even in phase opposition. For starting the motors from the individual main and auxiliary busbars, a momentary voltage drop of 20% referred to nominal voltage should be taken into consideration. With 85% of the nominal voltage applied to the motor terminals, each motor shall be capable of accelerating its associated load to full speed with a minimum accelerating torque of 5% of full load torque.

The maximum starting currents (without any tolerance) shall not exceed the following values:

i) 5 times of rated current for L.V. motors rated 100 kW or above,

ii) 2 times of rated current for D.C. motors (by means of starting resistors).

Generally, all motors shall be able to withstand three cold starts per hour, equally spaced. In addition, each M.V. motor shall be capable of enduring two successive starts with the motor initially at operating temperature. Each L.V. motor shall be capable of withstanding three successive starts under the same conditions or once every twenty minutes without detrimental heating.

Motors for frequent automatic starting shall have an adequate rating. In the motor list the Bidder shall state the frequency of starts permitted in compliance with the motor design.

6.4.5 Windings and Insulation Class

The insulation of all motors shall be of class F but maintain in operation the temperature limits of class B materials. It shall be suitable for operation in damp locations, for occasional contact with corrosive gases and vapours and for considerable fluctuations in temperature.

The stator winding shall be suitably braced to withstand the forces due to direct-on-line starting and transfer conditions as mentioned before. The winding envelopment

and tails shall be non-hygroscopic. The stator winding shall withstand the maximum fault current for the period determined by the associated protective devices.

The rotor winding (if applicable) shall be designed to give trouble-free continuous service including repeated direct-on-line starting. The rotor shall be subjected to a 120% over speed test for 2 minutes without showing any winding dislocation.

6.4.6 Ventilation and Type of Enclosure

All motors shall be of the totally enclosed fan-cooled type, protection class IP 54 according to IEC Recommendation 144. Cable termination points shall be of class IP 55.

They shall have a closed internal cooling air circuit re-cooled by an external cooling air circuit drawn from the opposite side of the driving end.

Where motors are installed outdoors, a weatherproof design shall be chosen. L.V. motors of IEC size 132 and above shall be equipped with automatically controlled heating elements for protection against internal condensation of moisture during standstill periods. Such A.C. heater shall be suitably fixed inside the motor casing; the leads shall be led to a separate L.V. terminal box.

Motors installed outdoors and directly subjected to solar radiation shall be rated such as not to exceed a maximum metal temperature of 85°C. Where necessary, such motors shall be provided with sun shields.

Vertical motors shall be provided with a top cover to prevent the ingress of dirt, etc.

6.4.7 Bearings

As far as possible, the motors shall have sealed ball or roller bearings lubricated for life. All other motors with ratings of about 1 kW and above shall be equipped with lubricators permitting greasing while the motor is running and preventing over-lubrication. Additionally, the bearings shall be fitted with grease nipples permitting the use of a universal grease gun.

Vertical motors shall have approved thrust bearings.

Where sleeve bearings are being used, they shall be of the self or forced lubricating type. If forced lubrication is required, it shall be arranged common to both the motor and the driven machine and provisions shall be made to ensure lubrication during start-up and shut down operations without the necessity to start an auxiliary lube oil pump. Self-lubricated bearings shall be equipped with an easily accessible oil reservoir with overflow pipe and oil collecting vessel.

All bearings shall be easily controllable during operation or standstill without dismantling the bearings. The bearings shall further be protected and sealed against dust penetration and oil leakage.

In case of independent bearings, motor and bearing pedestals shall be fitted on a common base plate.

For the transport of motors equipped with ball or roller bearings, special bearing inserts shall be provided to prevent transport damage.

Service hour meters shall be installed in the motor control centers if maintenance work such as re-greasing, oil change etc. depend on the operation time of the motors.

6.4.8 Shafts and Couplings

The motors shall be provided with a free shaft extension of cylindrical shape with key and keyway according to IEC Recommendation 72-1 and with the motor side coupling, which shall be pressed on the motor shaft and be balanced together with it. A coupling guard shall be provided.

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6.4.9 Brush Gear and Commutators

Brush gear for D.C. motors shall be designed to ensure constant brush pressure. Carbon brushes shall be provided which stand at least 6 months of operation without replacement. Each brush shall be independently adjustable but should not require adjustment throughout its life. A design of brush gear which permits the brush holder to touch the commutator as the brushes wear or which passes current through the pressure fingers will not be accepted.

A sufficient number of brushes, not less than two per pole, shall be fitted to ensure that vibrations do not affect the commutation.

The minimum safe wearing margin of commutators shall not be less than

20 (twenty) per cent of the total thickness of the commutator bars and the minimum safe diameter shall be clearly marked on it.

6.4.10 Terminal Boxes and Earthing

The terminal leads, terminals, terminal boxes and associated equipment shall be suitable for terminating the respective type of cables as specified in these General Technical Specifications and in the Particular Technical Specifications.

The terminal boxes shall be of ample size to enable connections to be made in a satisfactory manner. Supports shall be provided at terminal boxes as required for proper guidance and fixing of the incoming cable.

The terminal boxes with the cables installed shall be suitable for connection to supply systems with the short-circuit current and the fault clearance time determined by the motor protective devices.

A permanently attached connection diagram shall be mounted inside the terminal box cover. If motors are provided for only one direction of rotation, this shall be clearly indicated.

Terminal boxes shall be totally enclosed and designed to prevent the ingress of moisture and dust. All joints shall be flanged with gaskets of neoprene or similar material. For motors above 1 kW, the terminal box shall be sealed from the internal air circuit of the motor.

Depending on the size, the terminal box of L.V. motors shall be fitted either with an approved cable sealing-end or with a gland plate drilled as required and provided with suitable fittings for cable fixing and sealing. Such openings shall be temporarily plugged or sealed during transportation.

For earthing purposes, each motor shall have adequately sized bolts with washers at the lower part of the frame. In addition, each terminal box shall contain one earthing screw. Each equipment/panel shall be earthed by at least two separate earthing strips.

The cable termination philosophy to be adopted shall be such that extensive grouping of signals by large scale use of field-mounted group. JB'S at strategic locations (where large concentration of signals are available, e.g. switchgear) is done. Termination / Junction boxes shall have either maxi- terminal or cage clamp type terminals.

6.4.11 Noise-Level and Vibrations

Under all operating conditions, the noise level of motors shall not exceed 85 dB (A).

In order to prevent undue and harmful vibrations, all motors shall be statically and dynamically balanced.

Vibration displacements or velocity shall be measured in accordance with relevant IS for IEC motor sizes 80 to 315. The results for all motors shall be within the "R" (reduced) limits.

6.4.12 Tests

Each motor shall be factory tested and shall undergo a test at site. The following tests shall be performed under full responsibility of the Bidder.

i) **Workshop Tests:**

a) Measurement of winding resistances,
b) No-load and short-circuit measurements,
c) Measurement of starting current and torque,
d) Efficiency measurement (type test),
e) Heat test run,
f) Dielectric test,
g) Measurement of insulating resistance,
h) Over speed test.

ii) **Site Tests:**

a) Measurement of insulation resistance,
b) Measurement of motor vibrations,
c) Measurement of starting time.

6.5 Cubicles and Panels

All control cubicles/panels, switch gear panels and other cubicle/panel enclosures would be of cold rolled sheet steel. Cubicles/panels shall have full modularity along X-Y-Z axis made out of folded profile based structure with reference to the requirement of combinability of the panels which shall be finalized during detailed design with respect to the layout. The cabinets shall be totally enclosed, free standing type. Such structure shall be made by a sheet of not less than 2.0 mm. However, doors can be extracted through a sheet of 2.5 mm which could be of rigid construction and the sides where no instruments/MCB/relay is to be installed can be provided with a cover sheet of not less than 2.0 mm which shall be approved during detailed design based upon the construction of panel. Further top and bottom of the panels should not be less than 2.5 mm. The Load bearing elements shall be minimum 2.5 mm thickness. The structural frame shall have provision at a regular interval to facilitate retrofitting components without need of drilling holes. The design of all the cabinets and grouping/layout of all equipment, terminal blocks etc. shall be optimized, fully keeping in view the convenience of operation and maintenance personnel and shall be subject to purchaser's approval during detailed engineering

In case of junction boxes, small starter panels and muslin kiosks shall be made out from a single sheet of thickness not less than 2.5 mm which should have minimum weld interface except weld seal at the enclosing envelope. Door specification however, remain the same as of cubicles/panels having specific PU seal with reference to the IP class mentioned in the specification either under GTS or PTS.

Cubicles shall be fitted with close fitting, hinged, lift-off doors capable of being opened through minimum 120 deg. The doors shall be provided with door handles with integral lock and master key. The doors shall have PU seal for perfect sealing and longer life.

Bidder shall design the cabinet internal arrangement, floor cutout and cable gland plate such that all the cables entering or leaving the cabinet can be properly glanded in the gland plate. Cubicles and panels shall be vermin proof. Removable gland plates

shall be supplied and located to provide adequate working clearance for the termination of cables. Under no circumstances shall the floor/roof plate be used as a gland plate. The cables and wiring shall enter from bottom or top as approved or directed by the Engineer in-Charge. Bidder shall also provide after the final installation of the cable, a suitable fire proof sealing material on the gland plates to ensure absolute sealing of the cabinet bottom, thereby ensuring that no dust ingress takes place from the cable entry zones

The cubicles and panels shall be adequately ventilated, if required, by vents or louvers, and shall be so placed as not to detract from the appearance. All ventilating openings shall be provided with corrosion resistant metal screens or a suitable filter to prevent entrance of insects or vermin. Space heating elements with thermostatic control shall be included in each panel.

The cabinets/ panels shall be IP-54 protection class. The Bidder shall ensure that the packaging density of equipment in these cabinets is not excessive and abnormal temperature rise, above the cabinet temperature during normal operation or air conditioning failure, is prevented by careful design. This shall be demonstrated to the purchaser during the factory testing of the system. The Bidder shall ensure that the temperature rise is limited to 10°C above ambient and is well within the safe limits for system components even under the worst condition.

Where cubicles are split between panels for shipping, terminal blocks shall be provided on each side of the split with all necessary cable extensions across the splits. These cable extensions shall be confined within the panels with suitable internal cable ducts.

Unless stated otherwise, all cubicles and panels shall be provided with a ground bus with 40mm x 5mm or higher (as per requirement) copper bar extending throughout the length. Each end of this bus shall be drilled and provided with lugs for connecting ground cables ranging from 70 to 120mm2.

The standard phase arrangement when facing the front of the motor control centres and switchboard shall be RYB from left to right, from top to bottom and front to back. All instruments, devices, buses and other equipment involving 3 phase circuits shall be arranged and connected in accordance with the standard phase arrangement, where possible. Electrical clearances shall conform to applicable standards and shall not require cutting away of adjacent framework.

All instruments, control knobs and indicating lamps shall be flush mounted on the panels. Relays and other devices sensitive to vibration shall not be installed on doors or hinged panels, and no equipment shall be installed on rear access doors.

The instrument and control wiring, including all electrical interlocks and all interconnecting wiring between sections, shall be completely installed and connected to terminal blocks by the manufacturer.

The arrangement of control and protection devices on the panels and the exterior finish of the panels shall be subject to the approval of the Employer. The interior of all cubicles and panels shall have a matt white finish preferably.

Two spray coats of inhibitive epoxy primer-surface shall be applied to all exterior and interior surfaces. A minimum of 2 spray coats of final finish color shall be applied to all surfaces. The final finished thickness of paint film on steel shall not be less than 65-75 micron. Paint films which show sags, checks or other imperfections shall not be acceptable.

The finish colors for exterior and interior surfaces shall be finalized during detailed design.

The wires and wiring accessories, terminations etc. shall be as per relevant Indian/IEC standards.

Have internal wire gutter system with removable covers.

Have sufficient terminal blocks to accommodate all circuits with approximately 20 percent spare terminal points.

Have suitable locks with triplicate keys and master key for locking and opening of panel.

Switched interior light and socket outlets shall be provided for all cubicles and control panels light switch on front and rear side of the panel.

Have one duplex 15 amps, 240 V AC, 3 wire grounded type plug receptacle. Any additional requirement to be decided during detailed engineering.

All cubicles and control panels shall be provided with nameplates, identifying the purpose of the panel and all of its components.

All internal equipment and wiring shall be neatly and clearly marked as indicated on the schematic and wiring diagrams. Internal wiring and cables shall be marked with sleeve type engraved marking. Marking system and marking material shall be subject to approval by Employer. Identification of the respective conductors shall be in accordance with the requirements of IEC publication 60204. In cable, having five conductors or more the individual conductors shall be numbered throughout the entire length. In cables having less than five conductors colour coding in accordance with IEC Recommendations 60204 shall be used.

6.5.1 Starters and Contactors

Motor starters and contactors shall be equipped with short circuit protection and local disconnecting devices. Preferably, all starters shall be from one manufacturer. The control circuit voltage shall be obtained from a 415/240 V isolating transformer with primary circuit breaker and secondary fuse. The secondary winding of this transformer shall be grounded. The operating coils of the contactor shall be connected between the grounded side of the transformer and the control contacts.

Starters and contactors shall comply with IEC 292.1and be suitable for direct on-line starting, uninterrupted electrical duty, and capable of 30 operations per hour. They shall be installed in ventilated enclosures for indoor installation and weatherproof enclosures for outdoor installation, unless otherwise approved by the Employer. The enclosures shall be complete with locks, cable sealing boxes, conduit entries, cable gland plates, bus bars, internal wiring, terminal boards, etc. as required by the duty of the starter or contactor.

Starters and contactors shall be of minimum size compatible with motor size and capable of satisfactory operation, without damage, for a period of 5 minutes at a voltage 25 percent below nominal, at nominal frequency.

Thermal type overload and phase failure relays shall be supplied with starters for motors of 7.5 kW or greater. For motors of less than 7.5 kW, suitable rated 3-phase thermal overloads will be acceptable. Ammeters to read current in one phase shall be provided for motors above 7.5 kW.

Each starter shall have sufficient number of auxiliary contacts required for interlocking and indication purposes plus two spare convertible contacts for Owner's use.

6.5.2 Moulded Case Circuit Breakers

All moulded case circuit breakers shall be of 2 or 3-pole type as required, having thermal time delay and instantaneous trips with "On-Trip-Off", indicating/operating

mechanism. Circuit breakers used in combination type motor starters or contactors shall have the operating mechanisms interlocked with the starter or contactor cover so that the cover cannot be opened unless the circuit breaker is open. The breakers shall comply with applicable section of IEC 157/1 or equivalent standards.

6.5.3 Control Relays

Relays used as auxiliary control devices in conjunction with motor starters and magnetic contactors shall be of the type designed for machine tool application featuring contact convertibility. All contacts shall have a minimum thermal current rating of 10A over a range of 6 to 600 V AC.

6.5.4 Pilot Devices

Pilot devices such as selector switches, push-button starters and thermostats shall be of heavy duty type and, where mounted outdoors, shall be housed in weather proof enclosures specially designed for the environment.

All electrical contacts for control, alarm and shutdown shall have a thermal current rating of not less than 10 A at 220 V DC.

6.5.5 Terminal Blocks

All terminal blocks shall be mounted in an accessible position with the spacing between adjacent blocks not less than 100 mm and space between the bottom blocks and the cable gland plate being a minimum of 200 mm. sufficient terminals shall be provided to allow for the connection of all incoming and outgoing cables, including spare conductors and drain wires. In addition, 20 percent spare terminals shall be provided. In enclosed cubicles, the terminal blocks shall be inclined toward the door for facilitating terminations.

Terminals shall be of the channel mounting type and shall comprise a system of individual terminals so that terminal blocks can be formed for easy and convenient cabling consistent with the high reliability required of the circuits.

Terminal blocks shall be provided with shorting links and paralleling links where applicable and mounting identification numbers and/or letters.

Terminal blocks shall be disconnecting link type for CT, PT and incoming supplies AC/DC & for balance fixed link type conforming to the applicable standards. The smallest size to be used shall be designated for 2.5-sq. mm wire and not more than two conductors shall be connected under one terminal clamp.

Terminal identification shall be provided corresponding to wire number of connected leads.

Circuit terminals for 415 V AC shall be segregated from other terminals and shall be equipped with non-inflammable, transparent covers to prevent contact with live parts. Warning labels with red lettering shall be mounted thereon in a conspicuous position.

Control circuits and power circuits shall be completely separated by use of divided or separate terminal blocks.

The screw type modular Terminal Block should be manufactured as per IEC-60947-7-1. The insulating material of Terminal Block should be of polyamide 6.6 meeting V0/V2 inflammability Class as per UL 94. All metal parts including screws should be of copper alloy.

The Terminal Block should be suitable for mounting on both ‘DIN’ as well as ‘G’ type rail. All the metal parts should be captive and touch proof. The Terminal Block should have screw locking design so that it can withstand vibration level up to 5g. and also prevent accidental loosening of conductors. The terminal blocks shall also have necessary accessories like end clamp, separation plates etc.

Unless otherwise specified terminal blocks shall be suitable for connecting the following conductors on each side.

All circuits except CT/PT circuits : Minimum of two of 2.5 sq.mm copper flexible

All CT/PT circuits : Minimum of 2 nos. of 6 sq.mm copper flexible

6.5.6 Equipment Wiring

All wiring connections shall be readily accessible and removable for test or other purposes. Wiring between terminals of the various devices shall be point to point.

Splices or tee connections between terminal points are not acceptable. Wire runs shall be neatly trunked inside the panels or in wiring troughs. Whenever possible, unused areas of the panels shall be kept free of wiring to facilitate the installation of future equipment.

Multi conductor cables shall be connected to the terminal blocks in such a manner as to minimize crossovers. Approved claw washers of crimp type connector shall be used to terminate all small wiring. Each conductor shall be individually identified at both ends through a system providing ready and permanent identification, utilizing slip-on ferrules approved by the Engineer in-Charge.

Markers may be typed individually or made up from sets of numbers and letters firmly held in place. Open markers will not be accepted.

Markers must withstand a tropical environment and high humidity and only fungus proof materials will be accepted. Ferrules of adhesive type are not acceptable.

All trip circuits shall employ markers having a red background.

Sensitive control circuits shall be effectively shielded against extraneous signals and interference. A separate terminal shall be provided for termination of individual cable shields, which will be grounded at source end only.

6.5.7 Alarm Contacts

Where applicable, all alarm contacts shall be of galvanically isolated type and provide inputs to the following devices;

i) Local annunciator,

ii) Station annunciator,

iii) Supervisory control and sequence of events / fault recorder system.

All alarm contacts shall be changeover type. Where required, relays shall be provided as contact multiplier.

6.6 LV AC/DC Power and Control Cables

The scope of cabling works covers supply, testing at works, packing, forwarding, transportation, storage & preservation at project site, erection, testing & commissioning and remedial action, if any up to 3 years of defects liability period of LT power cables, DC power cables, control cables, cable lugs, glands, terminals and all other accessories . The scope of work also covers laying of power cables on cable trays / racks provided by other bidder and their termination on various panels, marshalling boxes, equipment etc. covered in this chapter as well as cabling, if required, between the equipment of this package/other packages in power house complex comprising underground machine hall and transformer hall caverns, GIS cavern, various tunnels, Pothead yard, Butterfly Valve Chamber, Control rooms at switchyard, surge shaft, TRT outfall, Dam site etc.

6.6.1 Technical Requirements

i) The cable shall be suitable for laying on racks, in ducts, trenches, conduits and underground (buried) installation with chances of flooding by water.

ii) Cables shall be armored type if laid buried under ground.

iii) Cables shall be flame retardant, low smoke and heat resistant (FRLS&HR) type designed to withstand all mechanical, electrical and thermal stresses develop under steady State and transient operating conditions as specified elsewhere in this specification.

iv) Conductors shall be multi stranded.

v) XLPE insulation shall be suitable for continuous conductor temperature of 90 deg. C and short circuit conductor temperature of 250 deg. C. PVC insulation shall be suitable for continuous conductor temperature of 70 deg. C and short circuit conductor temperature of 160 deg. C.

vi) The cable cores shall be laid up with the filters between the cores wherever necessary. It shall not stick to insulation and inner sheath. All the cables, other than single core unarmoured cables, shall have distinct extruded PVC inner sheath of black colour as per IS: 5831. For single core armoured cables, armouring shall be of aluminium wires.

vii) The Aluminium used for armouring shall be of H4 grade as per IS: 8130 with maximum resistivity of 0.028264 ohm-mm2/m. at 20 deg. C. The types and sizes of aluminium armouring shall be same as indicated above for galvanized steel.

viii) Outer sheath shall be of PVC black in colour. In addition to meeting all the requirements of Indian standards referred to, outer sheath of all the cables shall have the following FRLS properties:

a) Oxygen index of min. 29 (Test method as per IS 10810 part-58),

b) Acid gas emission of max. 20% (to IEC-754-I),

c) Smoke density rating shall not be more than 60% during Smoke Density test as per ASTMD-2843.

ix) For LT Power / Control Cables, cores of the cables shall be identified by colouring of insulation. Following colour scheme shall be adopted:

a) 1 core - Red or Yellow or Blue or Black,

b) 2 core - Red & Black,

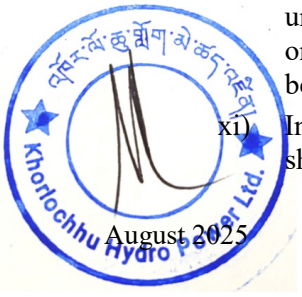
c) 3 core - Red, Yellow & Blue,

d) 4 core - Red Yellow Blue & Black.

For reduced neutral conductor, the core shall be black.

x) For Control Cables having more than 5 cores, core identification shall be done by numbering the insulation of cores sequentially, starting by number 1 in the inner layer (e.g. say for 10 core cable, core numbering shall be from 1 to 10). The number shall be printed in English numerals on the outer surfaces of the cores. All the numbers shall be of the same colour, which shall contrast with the colour of insulation. The colour of insulation for all the core shall be grey only. The numerals shall be legible and indelible. The numbers shall be repeated at regular intervals along the core, consecutive numbers being inverted in relation to each other. When the number is a single numeral, a dash shall be placed underneath it. If the number consists of two numerals, these shall be disposed one below the other and a dash placed below the lower numeral. The spacing between consecutive numbers shall not exceed 50mm.

xi) In addition to manufactures identification on cable as per IS, following marking shall also be provided over Outer sheath:



a) Cables size and voltage grade – To be embossed,
b) Word 'FRLS & HR' at every 5 meter – To be embossed,
c) Sequential marking of length of the cable in meters at every one meter – To be embossed/printed,
d) The embossing / printing shall be progressive, automatic, in line and marking shall be legible and indelible.

xii) All cables shall meet the fire resistance requirement as per Category-B of IEC 332 Part – 3.

xiii) Allowable tolerance on the overall diameter of the cables shall be +/-2 mm maximum over the declared value in the technical data sheets.

xiv) In plant repairs to the cable shall not be accepted. Pimples, fish eye, blow holes etc. are not acceptable.

6.6.2 Cable Selection & Sizing

i) The number of cores and sizes of the cables required for various circuits shall be calculated by the Bidder and got approved from the Employer during detailed design and engineering.

ii) The cables covered by these specifications shall be supplied in one length or in standard lengths as approved by the purchaser. Standard length of each type and size of cables shall be indicated in the offer.

iii) Cable lengths shall be considered in such a way that straight through cable joints are avoided.

iv) Cable shall be of armoured type if laid in pothead yard area or directly buried.

v) LT Power Cables shall be sized based on the following considerations:
a) Rated current of the equipment,
b) The voltage drop in cable, during motor starting condition, shall be limited to 10% and during full load running condition, it shall be limited to 3% of the rated voltage,
c) Short circuit withstand capability,

This will depend on the feeder type. For a fuse protected circuit, cable should be sized to withstand the let out energy of the fuse. For breaker controlled feeder, cable shall be capable of withstanding the system fault current level for total breaker tripping time inclusive of relay pickup time.

vi) Derating Factors

Derating factors for various conditions of installation including the following shall be considered while selecting the cable sizes:
a) Variation in ambient temperature for cables laid in air,
b) Grouping of Cables,
c) Variation in ground temperature and soil resistivity for buried cables.

vii) All LT power cables of sizes more than 120 sq.mm shall be XLPE insulated.

viii) 1.1kV Grade XLPE power cables shall have compacted aluminium conductors XLPE insulated, PVC inner sheathed (as applicable), armoured, FRLS PVC outer sheathed conforming to IS: 7098. (part-1)

ix) 1.1kV Grade PVC power cables shall have aluminum conductor (compacted type for sizes above 10sq.mm), PVC insulated, PVC inner sheathed (as applicable) armoured, FRLS PVC outer sheathed conforming to IS:1554 (Part-I).

6.6.3 Control Cables

All acceptance and routine tests as per specification and relevant standards shall be carried out including the following tests. Charges for these shall be deemed to be included in the equipment price.

i) Control cables shall be sized based on the following considerations:

a) The minimum conductor cross section shall be 1.5sq.mm,

b) The minimum no. of spare cores in control cables shall be as follows:

No of cores in cable	Min. No. of spare cores
2C, 3C	Nil
5C	1
7C-12C	2
14C & above	3

c) 1.1kV Grade Control cables shall have stranded copper conductor multi-core PVC insulated, PVC inner sheathed, armoured, FRLS&HR type PVC outer sheathed conforming to IS:1554(Part-I).

6.6.4 Cable Drums

i) Cable shall be supplied in non-returnable wooden or steel drums of heavy construction. The surface of the drum and the outer most cable layer shall be covered with water proof layer. Both the ends of the cables shall be properly sealed with heat shrinkable PVC/rubber caps secured by 'U' nails so as to eliminate ingress of water during transportation, storage and erection. Wood preservative anti-termite treatment shall be applied to the entire drum. Wooden drums shall comply with IS: 10418.

ii) Each drum shall carry manufacturer's name, purchaser's name, address and contract number, item number and type, size and length of cable and net gross weight stenciled on both sides of the drum. A tag containing same information shall be attached to the leading end of the cable. An arrow and suitable accompanying wording shall be marked on one end of the reel indicating the direction in which it should be rolled.

6.6.5 Tests

i) **Tests on Cables:**

The following tests shall be conducted on each type (voltage grade) and size of cable:

a) Insulation resistance test (Volume Resistivity method),

b) High voltage test,

c) Partial discharge test,

d) Bending test,

e) Dielectric power factor test,

- As a function of voltage,
- As a function of temperature,

f) Heating cycle test,

g) Impulse withstand test,

ii) **Tests on Cable Conductors:**

a) Annealing test : For copper conductors only

b) Tensile test : For aluminum conductor only

c) Wrapping test : For aluminum conductor only

d) Resistance test

iii) **Tests for Armor Wires / Formed Wires:**

a) Measurement of Dimensions,
b) Tensile Test,
c) Elongation test,
d) Torsion test (For round wires only),
e) Wrapping test (For aluminum wires/formed wires only),
f) Resistance test.

iv) **Tests for XLPE insulation & PVC Sheath**

Sl. No.	Test	
1	Test for thickness measurement of insulation, insulation screen, conductor screen and outer sheath	
2.	Tensile strength and elongation test before and after ageing	
3.	Ageing in air oven	
4.	Loss of mass test	For PVC outer sheath only
5.	Hot deformation test	For PVC outer sheath only
6.	Heat shock test	For PVC outer sheath only
7.	Shrinkage test	For PVC outer sheath only
8.	Thermal stability test	For PVC outer sheath only
9.	Hot set test	For XLPE insulation only
10.	Water absorption test	For XLPE insulation only
11.	Cold Bend Test	For outer sheath only
12.	Cold Impact Test	For outer sheath only
13.	Oxygen Index Test	For outer sheath only
14.	Smoke density Test	For outer sheath only
15.	Acid gas generation Test	For outer sheath only
16.	Flammability Test as per IEC-332 Part-3 (Category-B)	For completed cable only
17.	Heat cycle test	For complete cable only
18.	Impulse withstand test	For complete cable only

6.6.6 Cable Installation

The following are some of the salient factors which shall be kept in view during installation of XLPE/PVC insulated cables:

i) Before laying, the insulation of the cables shall be checked with megger as a preliminary check against any probable damage. A log book of such megger value shall be maintained by the bidder,

ii) The drum shall be rolled in the direction of arrow for rolling marked on the drum,

iii) The joints being the weakest point of the electric power transmission system, therefore the prefabricated type of joints shall be preferred otherwise necessary precautions/instructions of the Manufacturer for making joint at site shall be strictly followed and indicated in the bid,

iv) Minimum bending radius i.e. 12 times of the overall diameter of the cable shall be maintained.

6.6.7 Cable Termination

i) All cables that will be laid by the Bidder shall be terminated at both ends. The Bidder shall make all electrical connections strictly in accordance with the purchaser's cable schedule (prepared after detailed engineering showing allocation of cable routes made by the bidder) and shall provide numbered ferrules at each connecting terminal in order to check connections without any

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difficulty. One termination shall mean connecting both ends of one core of a cable.

ii) The various auxiliary equipment which are proposed to be installed in Khorlochhu HPL at various floors/locations where cable connections are required have been shown in the enclosed specification drawings.

6.6.8 Erection of Straight through joints

i) Straight through cable joints cable joints, wherever required shall be supplied and installed by the bidder. The bidder shall quote unit rates for straight through joints for different size of cables. The supply shall include necessary epoxy resin, jointing ferrules, tapes, plumbing material, etc. required for making the joint complete in every respect.

ii) Where the cable is to be jointed with existing cable, the sequence of cores at the two ends to be jointed shall be in the opposite direction, i.e. if at one end it is in clockwise direction, at the other end it shall be in anticlockwise direction. This is necessary to avoid the crossing of cores while jointing.

6.6.9 Earthing of Cables & Accessories

i) All bonding clamps at the joints and terminations of the armoured cables & the armour wires shall be solidly earthed. The clamps shall be adequately tightened. This is necessary to ensure proper electrical contact because armour is the only return path for earth fault current.

ii) In case of unarmoured cables, the external metallic earth bonding connector of adequate size should be used. Precautions should be taken to eliminate the chemical and bimetallic corrosion of the earth connectors or bonds.

6.6.10 Erection of Panel Cut-Outs and Gland Plates

i) The panels provided with cable gland plates in the bottom. A few panels shall have top cable entry for cables. Suitable holes in bottom/top cable entry gland plates will be done by the Bidder as required.

ii) The Bidder shall also be responsible for sealing the spare holes and panel cut-outs with the help of suitable gland plates or mutually agreed method. All materials are covered in the bidder's scope of supply.

6.6.11 Cable Accessories

i) The Bidder shall supply all the required accessories that may be found necessary during actual execution of the work within the quoted prices. No intermediate joint will be allowed in the run of any cable.

ii) Cable Lugs: The Bidder has to supply necessary lugs corresponding to the cable sizes given in the Schedule of Requirements. These shall be made of Aluminium or copper corresponding to the conductor of cables. The Bidder shall ensure that no bimetallic action takes place, between the Aluminium conductor of the cable and the cable connecting lugs.

iii) Cable Glands: The cable glands shall be made of brass duly electro-tinned in order to avoid corrosion and oxidation of the surface. The nipple threads shall be in accordance with IS: 1653. Glands shall provide neat, tight, dust and vermin proof termination. Glands shall be provided with rubber ring to hold the cables firmly when check-nut is slightly tightened. Glands shall be complete with suitable washers etc. Cable glands shall incorporate built-in facilities for earthing the armour of cables.

iv) Cable Marker Ferrules: The cable and wire markers shall be made of best quality material. Ferrules shall have deep, large and permanent marking of alfa-numerical symbols which can't be erased. Suitable sticker type ferrules for

power cables may be supplied. These shall be marked as per purchaser's cable schedule such that each core of each cable can be identified easily.

v) Self-Adhesive Marker: Self-adhesive marker in the form of strips of any one character which can be easily peeled from the backing cards and can be applied on the cable shall be supplied. The strips shall be water-proof duly marked with a special formulated ink with specific thermo-setting adhesive to withstand high temperature.

vi) Tags: Aluminium strip of 19 mm width and 2 mm thickness for making tags or any other better alternative (details to be furnished with the bid) for labels shall be supplied.

vii) Other Accessories: PVC tapes, cotton tapes etc. required for laying, termination, testing & commissioning shall be supplied. These materials & accessories shall be of good quality as per relevant IS.

6.7 Earthing System

Design & engineering, supervision, testing and commissioning of complete earthing system for powerhouse complex comprising machine hall & transformer/GIS hall caverns, main access tunnel, cable tunnel, tail race tunnel, outdoor 400kV pot-head yard, BFV chamber etc. shall be in the scope of KEM-1 package.

The Bidder of KEM-1 package shall also include the scope of design, engineering, supply, installation, testing and commissioning of complete lighting protection system for pothead yard, dam, desilting chambers, Chaplangchhu diversion scheme, surge shaft, and TRT outfall including chemical earthing sets and necessary hardware.

6.8 Explosion Proof Works

6.8.1 General

According to the kind of oils and fuels used, explosion in hazardous locations may be caused by standard type electrical works. Therefore, the installation in such locations shall generally be kept to a minimum with said works designed or installed in compliance with the latest issue of IEC recommendation 79 and the appropriate articles of the American National Electric Code (NEC) or the German VDE Standards 0165, 0170 and 0171.

6.8.2 Definition of Hazardous Locations

Hazardous locations shall be defined as follows:

Class 1, Div. 1 locations are those:

Where hazardous concentrations of inflammable vapours or gases exist continuously, intermittently, periodically under normal conditions of operation and maintenance and with normal leakage.

Where the breakdown or faulty operation of process equipment could release explosive concentrations of fuel and cause simultaneous failure of electrical works.

Class 1, Div.2 are those:

Adjacent to Div.1 locations which may occasionally be reached by hazardous concentrations, and where inflammable volatile liquids or gases are handled, processed, or used, but where concentrations are not normally hazardous because liquids or gases are handled in closed systems.

Where hazardous concentration is normally prevented by positive ventilation. These locations become hazardous only when the ventilation system fails.

6.8.3 Design Features

The design features of electrical works and /or circuits to reach explosion proof condition shall be selected with due regards to the place of installation and the kind of works.

The main features shall be as follows:

Pressure & flame –proof Enclosure:

All parts, which may ignite a hazardous atmosphere, shall have an enclosure of sufficient strength to withstand the maximum pressure caused by ignition of the most inflammable mixture of the gas involved. All necessary joints of such enclosures shall be provided with long fits (minimum 25 mm) and close clearances (equal or smaller than 0.6 mm) to cool the escaping flame and to prevent flame propagation to the outside atmosphere.

Oil Immersion:

The parts capable of igniting inflammable or explosive mixture shall be immersed in oil to such an extent as to prevent ignition of explosive mixtures above the surface of oil by means of sparks or hot gases produced under oil.

Increased Safety:

To obtain an increased degree of safety on electrical works, special measures shall be taken to prevent non-permissible high temperatures, sparks or arcs inside or outside of the works on which they don't occur under normal working operations.

Intrinsic Safety:

All electrical circuits or part of such a circuit shall be considered as intrinsically safe if neither during normal working operation nor under fault conditions explosive mixtures is ignited by means of arcs, sparks or any heat generation.

Any other approved feature not mentioned above but may be felt necessary during the course of execution.

All explosion proof works shall be of approved design and must have undergone type tests according to appropriate standards.

The selection of such works with reference to design features and allocation to hazardous groups shall be subject to approval by the engineer.

6.9 Labels and Plates

6.9.1 General

Labels and data plates shall be provided in accordance with applicable standards and as detailed hereunder.

The proposed material of the labels, size, exact label lettering and proposals for the arrangement of the labels shall be submitted to the Employer for approval.

Where applicable, designations in the selected local language shall appear above or to the right of the designation in the Contract language. The translations into and writings in the local language shall be submitted for approval.

6.9.2 Equipment Labels and Instruction Plates

Labels written in the Contract language shall be provided for all instruments, relays, control switches, push buttons, indication lights, breakers, etc. In case of instruments, instrument switches and control switches, where the function is indicated on the device, no label is required. The label shall be fixed close to the devices in such a way

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that easy identification is possible. Fixing on the dial glass of instruments will not be accepted. The wording shall conform to the wording used in engineering documents.

Each separate construction unit (cubicle, panel, desk, box, etc.) shall be identified by its Works identification number. Cubicles and similar units shall also bear this identification number on the rear side if rear access is possible. The overall designation of each unit shall be given in the Contract language and, if required, also in a selected local language. These labels shall be made of anodized aluminium / stainless steel with black engraved inscriptions, arranged at the top section of the units. Manufacturer's trade labels shall, if desired, appear in the bottom section of the units.

All Works inside cubicles, panels, boxes, etc., shall be properly labelled with their item number. This number shall be the same as indicated in the pertaining documents (wiring diagrams, Works list, etc.).

Instruction plates in the Contract and selected local language, the sequence diagrams or instructions for maintenance shall be fitted on the inside of the front door of the electrical switchboards.

6.9.3 Warning Labels/Cautionary Signs

Warning labels shall be made of synthetic resin with letters engraved in the Contract and selected local language, where required in particular cases.

For indoor circuit breakers, starters, etc., transparent plastic material with suitably contrasting Colours and engraved lettering would be acceptable.

Caution and warning signs must be displayed in English and Bhutanese Language i.e. Dzongkha.

Identification plates and instruction plates shall preferably be bilingual i.e. English /Dzongkha language.

Details are stated in the Particular Technical Specifications or will be fixed at a later date.

6.9.4 Labels for Conduits

The material shall be non-corrosive and the description be done with 4 mm high letters/figures.

6.9.5 Labels for Cables

Each cable when completely installed shall have permanently attached to each end and at intermediate positions as may be considered necessary by the Engineer in-Charge, non-corrosive labels detailing identification number of the cable, voltage, and conductor size.

The cable identification numbers shall comply with those of the cable list. All cables in cable pits and at the entry to buildings shall be labelled utilizing the aforementioned type of label.

6.9.6 Rating Plates

Works (hoists, machines, transformers, etc.) rating plates and other technical data/informative plates shall either be of the enameled type or be of stainless steel suitably protected after engraving with a transparent paint resistant to aggressive atmosphere and solar radiation.

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6.9.7 Single-Line Diagrams

Each switchgear room shall be furnished with a copy of the final as-built single-line diagram detailing all electrical data and denominations, separate for each individual switchgear/distribution board/MCC, placed under glass and frame/wall mounted at an approved location.

The same applies to the Station Single-Line Diagram one copy of which shall be arranged in the control room(s).

6.10 Key System for Electric Boards

Key interlocked switches shall be provided with locks for locking in the neutral position. Similar locks shall be provided for selector switches for locking the switches in any of the positions.

The locks or padlocks shall be coordinated for the different applications and shall be supplied with three keys. A key cabinet at the end of each board (distribution board, MCC, control cubicles, etc.) shall be provided for storing the keys of that board. All keys shall have six master keys to open any lock or padlock supplied. Each key shall have one identification label fixed above the key-hanging hook inside the cabinet.

The cabinet door keys shall be similar and shall be six (6) in number

7 Instrumentation and Control Equipment

7.1 General

All instrumentation and control equipment shall be of internationally reputed make having proven performance and acceptability in the field.

7.2 Design Criteria

7.2.1 General

The relevant chapters of this package shall be considered for I & C equipment as far as applicable. Special reference is made to cabling, wiring and labelling.

All components shall be of an approved and reliable design. The highest extent of uniformity and interchangeability shall be reached. The design shall facilitate maintenance and repair of the components.

The Works shall be pre-assembled to the highest extent in the Bidder's or Sub-Bidder's workshop, e.g., shop welding of thermometer wells and other connections, wiring of boards, desks, etc., including internal wiring and installation of devices shall be carried out. Fragile instruments shall be removed for transportation to site.

All components shall be suitable for continuous operation under site conditions.

Materials for instrumentation and control equipment, including piping material, which is exposed to the measured media, shall be selected accordingly.

All components shall be compatible with other electrical, electronic and mechanical Works.

All instrumentation and control functions shall be shown on the piping and instrumentation diagrams. The symbols to be used shall be in accordance with ISO standard. The identification system (tag numbers) shall be in accordance with the Works identification system and is subject to approval by the Engineer in-Charge. All measurements and alarms shall be listed in a measuring list of a standard form subject

to Approval by the Engineer in-Charge. For remote controls, a schedule of interlocks shall be provided. The features of automatic controls shall be shown in block diagrams.

Shielded cables shall be provided for the control and supervisory equipment where required.

7.2.2 Standards

If the Contractor intends to apply Standards and Regulations other than those specified, he shall provide the Engineer with two (2) sets of such documents, which shall be complete, unabridged and written in the Contract Language.

7.2.3 Sizes of Indicators, Recorders, etc.

The meters, instruments and recorders shall be of standard size, to be selected to guarantee unique appearance of switchgears, control panels, control desks, etc. The front glasses shall be of the anti-glare type. The scales shall be 90 degrees type for local control panels but must be 240 degrees type for control room instrumentation.

The control switches, adjusters, etc., on the panels and desks shall harmonize with the utilized indicator sizes.

7.3 Tests

The single components and pre-erected assemblies shall undergo functional and routine tests in the Contractor's or Sub-Contractor's workshop. The ready mounted control and supervisory system shall undergo functional tests on Site prior to commissioning of the power Works.

Calibration tests shall be made on all-important pressure gauges and other instruments as required by the Engineer.

7.4 Measuring Systems

Electric measuring signals of 4-20 mA shall be transmitted to the control room. The output signal of transmitters shall be 4-20mA and linear over the whole measuring range.

The components shall quickly respond to any changes of the measured magnitudes. Measuring ranges of indicators, transducers, etc. shall be selected in such a way that the rated value of the measured magnitude covers approx. 75% of the range.

All local instruments shall, as far as practicable, be mounted vibration free to allow good reading. Wherever required, damping elements shall be used.

Corresponding systems shall be grouped together in local panels.

All local indicating instruments and test connections shall be included in the respective Works as integrated parts. The scope of local indicating instruments and test connections shall enable the operator to properly survey the Works and shall also allow to adequately carrying out all acceptance and other tests.

The binary sensors shall be fused separately and supplied with 24 V D.C.

All sensors, transducers, switches, gauges, meters, actuators, etc., upon approval of Engineer, shall be supplied from the approved sub-vendors/manufacturers listed in Attachment-9(i) of Form-1: Letter of Tender in Volume-2.

7.4.1 Flow Measurements

The primary elements of flow meters shall be standard Venturi tubes, pitot tubes, standard orifices, anubar inductive or ultrasonic type. Their design and performance shall be in accordance with applicable standards.

The design and arrangement of tapping points, piping and valves shall be in accordance with VDI/VDE rules 3512.

Beginning at a rate of flow of at least 5% of the measuring range all flow transmitters shall measure correctly. The error limit shall be ±2% for a rate of flow higher than 10%. The error of the primary elements is not included in this accuracy. The root extraction of flow measurement shall be effected electrically within the transmitter.

Arrangement:

The arrangement of the throttling devices, the straight lengths upstream and downstream from the throttling device shall be in accordance with the said standards. Bends shall be at a sufficient distance upstream from the throttling device, particularly when large orifice ratios are used.

7.4.2 Temperature Measurements

All wells for capillary type thermometers, resistance temperature sensors and thermocouples shall be of the weld-in type. Wells for thermometers and temperature sensors of the screw-in type shall be restricted to measuring points for lubrication oil, and to such measuring points where welding is not suitable, e.g., at cast-iron parts. Shop-welded thermometer wells shall be covered by screw caps for protection during transportation and erection.

Resistance thermometers and thermocouples shall be equipped with waterproof connection heads. Thermometer arrangements shall be such that the connection heads do not become warmer than 80 °C, and the measuring inserts are easily exchangeable.

The temperature sensors shall be selected in such a way to minimize the number of different spare inserts. Resistance thermometers shall be used as far as possible and shall generally be of type Pt 100. Double resistance thermometers (with two resistors in one insert) should be avoided.

The use of dial-type contact thermometers shall be restricted to bearing metal and oil temperature measuring. In all other cases, thermocouples or resistance thermometers and electric contact modules (monitors) shall be used. Glass thermometers or similar will not be accepted as contact thermometers.

7.4.3 Pressure Measurements

Pressure gauges shall be shock and vibration-proof (filling with glycerin) and shall be equipped with toothed wheels and toothed segments of the machined type. They shall completely be made of stainless steel.

Higher than rated pressure shall not deteriorate the pressure gauge or affect its calibration. The pressure gauges shall be equipped with a radial-connecting stud, to allow the mounting on a gauge holder.

The accuracy for the pressure gauges and pressure switches shall not be less than +/- 0.5% FSR. The error for pressure transmitters shall be limited to ±0.5%.

Pressure gauges and transmitters for inflammable liquids shall have filled systems and the filling liquid shall be separated from the inflammable liquid by means of adequate isolating membranes.

Each gauge, pressure switch and transmitter for absolute or differential pressure shall be equipped with a pressure gauge isolating valve including a test connection of the screwed type M20 x 1.5 mm so that such device can be removed without any disturbance of the plant operation.

Pressure gauges and transmitters for pressures of 10 bar and above shall not be directly mounted on the pressure tapping point. They shall be mounted apart from the tapping point on gauge holders or gauge boards. Whenever possible, pressure gauges and transmitters shall be group wise combined on racks or consoles.

Pressure gauges for high pressures shall be equipped with a relieve valve for safety reasons in case of leaks (with a rubber reverse flow check).

In case of flowing substances, the measuring point shall be selected in locations of undisturbed flow.

If the pressure is pulsating, the devices concerned shall be connected via flexible tubes or other pulse-absorbing means.

In general, all pressure gauges, transmitters and pressure contacts shall easily be accessible for maintenance and supervision.

The scales shall have preferably a diameter of 150 mm with black letters and figures on a white ground. The calibration shall be in "bar".

The adjustment of the pointer shall be possible by means of an adjustment device without removing the pointer from its axle.

The high and low-pressure connections of differential pressure gauges shall be marked accordingly.

All casings shall be dust and watertight made of stainless steel having preferably IP67 protection class and be provided with toughened glass.

7.4.4 Level Measurements

The liquid level measurements in reservoirs and tanks with atmospheric pressure shall be made by means of pressure transmitter of mercuryless-type, by displacement-type transmitters or float-disc-transmitters. The errors shall not exceed ± 1.0% of the total measuring range. Level switches shall be of the externally mounted float or displacement operated type. The switch shall be of packing less construction; there shall be a minimum of moving parts.

7.4.5 Electrical Measurements

All Electrical instruments shall be of flush mounted design, dust and moisture-proof. A.C. ammeters and voltmeters shall not be less than 1.5 accuracy class for connection to the secondary side of instrument transformers. D.C. measuring instruments shall have digital type systems of the same accuracy. Watt meters/energy meters shall have electro-dynamic measuring mechanisms if fed by transmitters. Watt meters shall be suitable for unbalanced systems and accuracy of energy meters should be of 0.2 % accuracy class or better.

All indicating instruments shall generally withstand without damage a continuous overload of 20% referred to the rated output value of the corresponding instrument transformers. Ammeters shall not be damaged by fault-currents within the rating and fault duration time of the associated switchgear via the primaries of their corresponding instrument transformers.

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All instruments and apparatus shall be capable of carrying their full load currents without undue heating. All instruments and apparatus shall be rear connected, and the enclosures shall be earthed. Means shall be provided for zero adjustment of instruments without dismantling.

All voltage circuits to instruments shall be protected by MCB's in the unearthed phases of the circuit, installed as close as practicable to the instrument transformer terminals, or, where instruments are direct- connected, as close as practicable to the main connection. All power factor indicators shall have the star point of their current coils brought out to a separate terminal which shall be connected to the star point of the current transformer secondary windings.

When more than one measured value is indicated on the same instrument, a measuring point selector switch shall be provided next to the instrument and shall be engraved with a legend specifying each selected measuring point.

All instruments shall be of the flush mounting type and shall be fitted with non-reflecting glass and shall comply in every respect with the requirements of IEC Publication 51.

Scales shall be arranged in such a way that the normal working indication is between 50-75% of full-scale reading permitting an accurate reading. CT connected Ammeters provided for indication of motor currents shall be provided with suppressed overload scales of 2 times full scale. The dials of such ammeters shall include a red mark to indicate the full load current of the motor.

Instrument scales shall be submitted for approval by the Engineer. All instruments mounted on the same panel shall be of same style and appearance.

Transmitter connected ammeters (for example those in mosaic-type control desks) shall have 90 degrees or 240 degrees circular scales calibrated 0-120 %. The rated motor current shall correspond to 100% scale indication.

All metering circuits shall be terminated in marked terminal blocks for remote metering purposes.

Measuring Converters

The converters shall be suitable for direct connection to the secondary circuits of the potential and current transformers used, or other sensors, each as they apply. The converters shall be static type, having all accessories to provide an output signal of 4-20 mA, filtered DC.

For the measuring converters the following minimum requirements shall be fulfilled:

i) Current transducers shall be single-phase, of accuracy class 0.2 or better,
ii) Voltage transducers shall be single-phase of accuracy class 0.2 or better,
iii) W and VAR transducers shall be two elements, three-phase. Accuracy class of the transducers shall be 0.2 or better.

Measuring Transformers

i) Potential transformer secondary windings shall be rated 110/√3 V.
ii) Current transformer secondary windings shall have a rated current of 1A/5A.

7.4.6 Position Measurements

Position transmitters of the potentiometer type will not be accepted. Inductive or capacitive type shall be provided.

Position transmitters for continuous position indication and measuring transducers shall have an output current of 4-20 mA and aux. supply voltage (if required) 220 or 48 V D.C. The "potentiometer-type" position measuring principle is not permitted.

7.4.7 Limit Switches

Limit switches shall be provided for each electrically operated gate, valve or gantry to automatically stop the motor at both ends of travel. Additional switches shall be provided where necessary for control, interlocks and indication.

Limit switches shall be mounted suitable for easy adjustment and for rigidly locking in position after being adjusted. They shall be of heavy-duty rating and have two changeover contacts suitable for 220 V D.C. operations.

Switch fixings shall be positive and shall be unaffected by vibration. At the same time they should be capable of easy adjustment to suit changing parameters of the associated plant.

Particular attention shall be paid to potentially harmful environmental conditions, including water, oil, dust, dirt, temperature variations and differential expansions. Where switches operate through linkages, precautions shall be taken to eliminate variations of settings and incorrect operations resulting from wear or tolerances.

All the limit switches shall be of IP 65 Protection Class.

7.4.8 Contact Devices

Contacts of level switches, pressure switches, temperature switches, limit switches, and of all other devices shall be of the snap action type (SPDT). Contact devices for interlocking systems shall be separate, i.e., contact devices serving commonly for interlocking and other purposes will not be accepted.

7.4.9 Protection Systems

Electrical/Mechanical Protection and Interlocking Systems shall be provided for all works components and individual systems to ensure a safe and reliable operation and to limit harm and damage to personnel and works to an utmost extent.

The primary functions of these facilities shall be to disconnect selectively faulty sections of the systems prior to influence or damage to other works and to maintain operative systems as far as possible.

Moreover, these devices shall facilitate the duty of the operation staff and prevent mal operation.

7.5 Transmitter Racks and Piping

Wherever practicable, transmitters for flow, pressure, etc., shall be installed in readily accessible positions in the proximity of the measuring point, free from vibration and protected against damage, moisture, dust, corrosive air, and great temperature changes.

The transmitters shall be grouped and assembled as far as practicable on local transmitter racks or in cubicles with glass or plexi-front.

The connecting lines between the primary elements and the transmitters shall be installed to falls in order to ensure that no air pockets or water locks are created.

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7.6 Control and Monitoring

The system shall be controlled and monitored by the SCADA system. The details of control and monitoring requirement are defined in the relevant chapter of the respective package.

The control by the SCADA system shall be through Unit Control Boards/Local Control Boards. All information that is necessary for comprehensive, convenient and selective control and monitoring of the system by the SCADA system shall be transmitted through Unit Control Boards/Local Control Boards. The unit control Board and local control boars shall be provided with surge protection device. The surge protection device shall be tested with IEC 61643-1. The surge arrester shall be pluggable type and should have indication for life.

It shall be the responsibility of the Bidder to make all necessary provisions required to achieve seamless and compatible interfacing of control and monitoring systems of generating units and other equipment with plant SCADA system.

Provisions of all transducers/ sensors, instruments, gauges for mechanical parameters (temperature, pressure, flow, vibration, etc.) and electrical parameters (current, voltage, frequency, power, MVAR, KWH, etc.) and spare contacts of relays, breakers, isolators push buttons, control/selector switches etc. from various equipment for monitoring, alarm, annunciation, control function etc. through plant SCADA system are in the scope of this contract.

Interconnection from various equipment to Local Control Cubicles and Unit Control Boards/Local Control Boards and all necessary interfaces, like I/O modules, PLCs, CPUs etc., required for communication between local panels/Local Control Cubicles of various auxiliaries/ equipment and respective Local Control Boards shall be covered under scope of this contract.

For connecting marshalling box/junction box with various equipment in field, multi-pin plug connector system shall be used, if feasible. The contact carriers shall have two capacitive PE contacts each to give the proper earthing to the system and it shall be suitable for electrical data equivalent to 250V/10A. The contact type shall fulfil the requirement of IEC 60 352/DIN EN 60 352. The contact carriers shall be covered by housing made up of polyamide 6.6 of V0 inflammability class in accordance with UL 94 and fulfil the requirement of IP54 at least. The housing shall be directly sealable on the mounting wall without the need of any kind of wall mounting base. The complete arrangement shall be highly reliable even under harsh conditions, due to high degree of protection.

It shall also be possible to control locally the main elements of the system from local control cubicles. Local control shall be performed in a standalone manner independent of SCADA system, and all information (faults, alarms, measurements, status) necessary for such control shall be displayed locally. Provision of control selector switch for selection of control through Local Control Cubicle, Unit Control Board/Local Control Board and plant SCADA system shall be made in Local Control Cubicles and Unit Control Boards/Local Control Boards.

If the system consists of redundant subsystems, the priority of operation of such subsystems shall be selectable, either from SCADA system or locally.

All control and monitoring equipment shall have communication interface compatible to IEC 61850 or IEC 60870-5-104.

7.7 Power Supply for Control and Monitoring

A reliable surge protected power supply shall be provided for powering the electronic circuits of the equipment/component. The power supply shall be from two independent DC station battery source, one as primary and other as secondary. Switchover from primary to secondary will follow automatically on failure of primary and return to the primary source automatically following restoration of primary supply. The primary source of supply and the charger of the battery should be protected with surge protection device. The surge arrester should be pluggable type and should have indication to show its life.

The power supply shall include redundant converter (dc-dc) connected to station battery source such that failure of any regulated output voltage shall cause instantaneous transfer to a redundant converter without affecting normal operation of the equipment/component in any way. Contacts shall be provided to alarm on power supply failure and local indication shall be provided to identify the failed functional block. The Bidder shall provide full details of the proposed power supply system for approval by the Employer.

In case AC supply is required for any control function, same shall be sourced from two online UPS, with one main and other standby and with automatic change over facility.

7.8 Key System for Electric Boards

Key interlocked switches shall be provided with locks for locking in the neutral position. Similar locks shall be provided for selector switches for locking the switches in any of the positions.

The locks or padlocks shall be coordinated for the different applications and shall be supplied with three keys. A key cabinet at the end of each board (distribution board, MCC, control cubicles, etc.) shall be provided for storing the keys of that board. All keys shall have six master keys to open any lock or padlock supplied. Each key shall have one identification label fixed above the key-hanging hook inside the cabinet.

The cabinet door keys shall be similar and shall be six (6) in number.

8 TRANSPORT, PACKAGING AND STORAGE

8.1 General

Shipping, loading, transportation, unloading, storage, erection and test running shall be performed by the Bidder.

From the time of manufacturing until commissioning all parts of the plant shall be protected and insured at the Bidder's expense against damage of any kind. Parts, which are damaged during transport, storage, erection or trial operation, shall be replaced at the Bidder's expense.

The packaging and storage of electronic equipment shall be strictly in accordance with internationally accepted standards. Electronic equipment shall be packaged, shipped and stored in anti-static packing. All packages shall be stored indoor. Packages containing electronic equipment shall be stored in humidity controlled environment. If required, dehumidifier shall be deployed by Bidder to control the condition of storage space. Storage of the equipment till commissioning is responsibility of the Bidder.The Bidder shall provide the Engineer in-Charge with complete packing lists of each performed shipment.

8.2 Packing

The bidder shall prepare all plant, devices & materials for shipment to protect them from damage in transit & shall be responsible for make good all damages due to improper preparations, loading or shipment.

After the workshop assembly& prior to dismantling for shipment to the site, all items shall be carefully marked to facilitate site erection. Wherever applicable, these markings shall be punched or painted so they are clearly visible.

Dismantling shall be done into convenient sections, so that the weights & sizes are suitable for transport to site & for handling on the site under the special conditions of the project.

All individual pieces shall be marked with the correct designation shown on the Bidder's detailed drawings and other documents (packing lists, spare part lists, in Operating and Maintenance Instructions, etc.).

Marking shall be done preferably by punching the marks into the metal before painting, galvanizing, etc., and shall be clearly legible after painting, galvanizing etc. In labelling, the Bidder shall endeavour to use as few designations as possible and each part of identical size and detail shall have the same designation, regardless of its final position in the plant.

All parts shall be suitably protected against corrosion, water, sand, heat, atmospheric conditions, shocks, impact, vibrations, etc.

All electrical parts shall be carefully protected from damage by sand, moisture, heat or humid atmospheric conditions by packing them in bio- degradable packing material. Where parts may be affected by vibration, they shall be carefully protected and packed to ensure that no damage will occur while they are being transported and handled.

The material used for shipment of material frame at manufacturer’s works withstanding the above shall be preferably environment friendly. Biodegradable packing shall be used to the extent possible.

The Engineer reserves the right to inspect & approve the packing before the items are dispatched but the bidder shall be entirely responsible for ensuring that the packing is suitable for transit & such inspection will not exonerate the bidder from any loss or damage due to faulty packing.

The impact recorder shall be provided with the consignment for monitoring shipments where concealed damage is the key concern.

8.3 Marking

The Bidder shall mark all containers with the implementing document number pertinent to the shipment. Each shipping container shall also be clearly marked with following information on at least two sides:

i) Consignee,
ii) Contract No.,
iii) Country of Origin,
iv) Port of entry,
v) Item number (if applicable),
vi) Package number, in sequence and quantity per package,
vii) Description of Works,

viii) Net and gross weight, volume.

8.4 Transport, Handling and Storage

The Bidder shall inform himself fully as to all relevant transport facilities and requirements, loading gauges and other limitations and shall ensure that the equipment as prepared for transport shall conform to such limitations. The Bidder shall also be responsible for obtaining from the Indian railway or highway authorities any permit that may be required for the transport of loads exceeding the normal gauges.

The Bidder shall provide means for all unloading and reloading for all consignments of plant; both during transport to Site and on the Site. Consignments shall be unloaded immediately on arrival at Site. The Bidder is required to take the necessary steps in order to provide the carriage, special supporting structures for heavy loads, etc.

All parts of the plant shall be brought, as far as possible, to their final place of erection. The Bidder shall construct their own storage facilities at site.

The storage facilities/warehouse shall be constructed at site as per manufacturer's instruction for equipment storage or other relevant standard. The manufacturer's guidelines or relevant standard for site storages shall be furnished to the Employer prior to the construction of the site storage facilities. The interim payment shall be released only upon the approval and construction of the site storage facilities. The Contractors shall consider the cost of such facilities in their price bid.

The warehouses shall be weatherproof, with good ventilation and solid floors. The floors of the warehouses and storage areas shall be designed to carry the loads imposed on them by the stored parts. The following parts shall be stored inside enclosed warehouses:

Bolts, pins, packing, tools, insulation materials, electrical parts with electrical devices attached, electric motors and excitation equipment, instruments, welding material and equipment, all small parts and all parts of the plant which already have been finally painted.

If large parts are stored in the open air, they shall be provided with weather resistant and fire-resistant covers. Electrical parts, which are not packed suitably and those so packed, but whose packing has been damaged shall be kept in suitable places from the moment of storage to the moment of installation.

All insulation materials which will be taken from the warehouse for installation and which are stored temporarily in the station shall be protected from weather or humidity.

All the equipment shall be stored as per standard storage and preservation instructions etc. of the suppliers.

9 PREPARATION AND INSTALLATION

Prior to commencement of installation, the Bidder shall closely inspect the site and all the foundations and other structures on which parts of the plant supplied under this Contract will be installed; he shall check that the foundations conform to the installation drawings.

The result of this check shall be reported to the Engineer in due time to allow any errors to be corrected before the commencement of erection. All parts of the plant shall

be cleaned carefully of all contamination such as dust, sand, rust, mill scale and other dirt prior to installation.

The Bidder has to do all the work related to assembly, erection, testing and commissioning complete in all respects. All necessary tools, plants, labour, materials including consumables for performing installation, testing and pre-commissioning shall be provided by the Bidder.

The Bidder shall submit the necessary data/information, layout and foundation/support drawings well in advance.

The Bidder shall provide and install the concrete inserts/embedment; support steels and/or components for foundation/supports purpose as per approved erection drawings and coordinate the activities with civil bidders to keep his activities in synchronism with civil work. All installation for foundation shall be verified and accepted by the Employer.

The Bidder shall use anchor fasteners for installation of piping, fixtures, mountings, conduits, cabling, panels etc. Chipping of concrete and/or taking support from reinforcement bars shall not be allowed.

The design, location and approval tests of anchoring rings for the fixing of lifting apparatus necessary for assembly and dismantling of equipment and plant accessories shall be the responsibility of the Bidder.

9.1 Reference Points

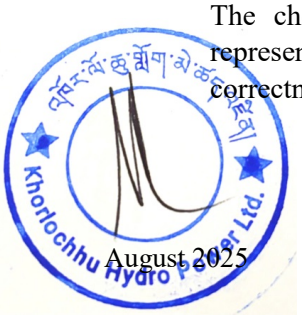
The Bidder shall employ a competent surveyor for setting-out of all datum lines including the constant checking and maintenance of the setting-out until the completion of his works.

The Bidder shall provide all necessary pegs, profiled templates and centre lines and shall establish all such permanent markings and recovery marks as may be required by the Engineer for checking the Bidder's setting-out. The Bidder shall be responsible for rectifying, at his own cost, all work rejected by the Engineer in-Charge due to errors in setting-out.

All bench marks, notch marks, pegs and signals on the surface, alignment pins and the like put in by the Engineer in-Charge for the purpose of checking the Bidder's work or as permanent survey marks will be under the care of the Bidder during the period of the Contract. He shall, at his own expense, take all proper and reasonable care and precautions to preserve and maintain them in their true position where such marks are within or adjacent to his work area. In the event of their being disturbed or obliterated by any cause whatsoever, they may, if so determined by the Employer, be replaced by the Employer at the Bidder's expense.

The Bidder shall be responsible for the true and proper staking-out of the works and levels of reference given by the Employer in writing, for the correctness of the positions, levels, dimensions and alignment of all parts of the works and for the provision of all necessary instruments, appliances and labour in connection with this.

The checking of any staking-out or of any line or level by the Employer's representative shall not in any way relieve the Bidder of his responsibility for its correctness.



9.2 General Notes on Installation Work

All transportation and handling of the plant from the place of storage to the place of installation shall be carried out by the Bidder. He shall provide all hoisting equipment, staging and scaffolding, winches and wire ropes, slings, tackles and all other appliances and temporary materials. The erection staging and scaffolding shall be provided with coverings and barriers and shall guarantee safe working conditions.

The Bidder shall comply with all applicable and approved safety regulations while carrying out the works on Site and with all reasonable requirements of the Employer. This stipulation shall in no way release the Bidder from any obligation concerning his liability for accidents and damages. He shall be responsible for adequate protection of persons, plant and materials against injuries and damages resulting from his operations.

The plant or parts to be installed shall not be overstressed during the process of installation.

The Bidder shall be responsible that the installation of all plant is properly executed to the correct lines and levels and in accordance with the manufacturer's instructions and the Contract requirements.

The alignment of the plant shall be done exactly; the tolerances indicated by the Manufacturers or in the drawings shall be kept.

Setting of parts to be aligned shall be performed by means of fine measuring instruments. All erection clearances and settings shall be recorded. Copies of these records shall be given to the Engineer. After alignment, the parts shall be held firmly in position by means of set pins, fitted bolts, etc.

All parts to be embedded in concrete shall be set accurately in position and shall be supported rigidly to prevent displacement during the placing of concrete. Adjusting screws and bolts shall be drawn tight and secured adequately. Steel wedges shall be secured by welding. Wooden wedges shall not be used.

For leveling and centering of all equipment's foundation, foundation plates, sole plates, brackets, housing, bearing etc., a maximum of five (5) numbers of shims (stainless steel plates) grading shall be allowed. Bidder shall strictly adhere to this specific installation requirement and accordingly design and supply the required grading of stainless steel shim/plates for foundation preparation and installation.

The Bidder shall verify carefully the position of all parts to be embedded before concrete is poured. All important measurements and dimensions shall be recorded. Copies of these records shall be given to the Employer for checking and approval before items are built-in to the Works.

After concreting, the control measurements shall be verified again, indicated in the above-mentioned records and submitted to the Employer.

The Bidder shall provide all necessary anchors and braces to ensure the alignment and stability of the parts to be installed. All temporary anchors and bracings shall take care of all dead load, wind load, seismic and erection stresses, e.g., during concreting, and shall remain in place until they can be removed without endangering the stability of the plant.

Welding, torch-cutting and drilling work on the plant to be erected shall only be carried out with the approval of the Engineer only for modification if any.

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If for installation purposes auxiliary structures have been attached to the plant, they shall be removed after completion of work and the surface restored to proper condition by grinding and repainting.

Special care shall be taken not to damage surfaces of galvanized or specially treated plant during erection. Care shall be taken to prevent or remove any rust streaks or foreign matters deposited on galvanized or otherwise finished surfaces during storage or transport or after installation.

Glass parts or other parts, which can easily be damaged, shall be provided with suitable protective sheaths or coverings during installation.

Machined or bare metal surfaces, which are to receive no coat of paint, shall be protected during transportation, storage and erection by a suitable anti-corrosion film.

All power tools preferably be operated pneumatically. They are to be handed over at the end of the installation work in good condition in accordance with the Employer's instructions.

After erection, the works shall be finally painted, in accordance with the painting specification, and any damaged paintwork shall be restored.

The Bidder shall keep the site in clean condition during erection and commissioning time. On instruction of the Employer, he shall remove waste from the place of installation to the defined deposit site at his own cost.

The assembling and installation of equipment are anticipated to be performed in parallel with civil works under worst conditions and the bidder shall provide all protection against dusts, water, welding/painting fume, etc. The Contractors shall consider the cost against such protection/arrangement in their price bid.

Installation Procedures

The Bidder shall use anchor fasteners for installation of piping, fixtures, mountings, conduits, cabling, panels etc. Chipping of concrete and/or taking support from reinforcement bars shall not be allowed.

The design, location and approval tests of anchoring rings for the fixing of lifting apparatus necessary for assembly and dismantling of equipment and plant accessories shall be the responsibility of the Bidder.

9.3 Civil Site Work

The following works shall be carried out as part of the civil works contract and is not included within the scope of work covered by the equipment specifications:

i) All concrete work, including reinforcement and form-work, and all grouting required for filling in, around and under the various parts of the works to be embedded in concrete,

ii) All necessary excavation and backfilling/ concreting required for installing the plant in its final position, unless otherwise stated in the Particular Technical Specifications,

iii) Building in of all required parts into the first stage concrete. The readiness of such parts shall be communicated to the Employer and they shall be delivered in due time by the Bidder unless otherwise specified or agreed in the Contract,

iv) Providing and grouting the blackouts for all anchoring and foundation bolts needed to support and fix the plant in its final position,

v) All protective measures, e.g., pumping, etc., to keep the various parts of the plant and the erection site free from water during the time of erection,

vi) Provision of cable and pipe ducts, trenches, block-outs, drilling for grounding system etc., in accordance with the drawings supplied by the Bidder and supervised by the Bidder,

vii) Adequate safety covers and protective measures against injury or damage to the Bidder's employees and equipment and to the works due to any operations of the civil bidder,

viii) Anchors may be provided with concrete pads & with embedded plates, of appropriate size at mutually agreed height(s) and spacing on upstream and downstream walls,

ix) Embedded plates and hooks of specific design and requirement in different floors, ceiling, walls etc. in accordance with the first and stage embedment drawings shall be supplied by the Bidders.

The Bidder shall level and adjust all parts of the equipment on the foundations and after each item is set up and the Employer's approval obtained, grouting or concreting will be carried out by other bidders and verified by the Bidder. The Bidder shall be responsible for ensuring that such work is carried out to his satisfaction and that level and adjustments made by him are not disturbed by the grouting operation. The Bidder shall be responsible for ensuring that the positions, levels and dimensions of the Works are correct according to the drawings notwithstanding that he may have been assisted by the Employer in setting out the said position, levels and dimensions.

9.4 Cable Laying

Wiring between equipment enclosures shall be made with cables, laid in trenches and/or cable trays and in cable conduits. The Bidder shall submit for review to the Employer a cable route layout-showing location of trenches, conduits and trays. All material for cable laying such as cable trays supports and fastening material shall be furnished and placed by the Bidder. Cables shall be properly fastened and marked where they enter enclosures by either cable clamps or nipples.

9.5 Embedded Parts and Anchor bolts

All embedded anchor bolts, rods, welding plates and support plates shall be provided. Anchor bolts shall consist of a threaded steel rod installed inside a pipe sleeve to provide lateral adjustment after the sleeve is embedded. The embedded end of the rod shall be provided with a steel plate, which shall be welded to the rod and sleeve to provide anchorage and to prevent entry of concrete into the sleeve during installation.

The threaded end of the rod shall be provided with two steel nuts and two steel washers to permit levelling and anchoring the equipment prior to grouting.

Approved types of expansion or chemical anchors shall be used where practicable for small equipment.

9.6 Installation Records

The Bidder shall maintain the installation records including installation quality control (QC) records of each activity to ensure quality of installation as per specification/requirement. The QC record shall clearly show the achieved erection tolerances vis-à-vis the allowable limits. The installation records shall be submitted to Employer for approval/acceptance to establish completion of installation milestones as per program of performance. All installation records shall be compiled and

submitted to the Employer before taking over the respective unit. Completion certificate for any work shall be issued only after approval/acceptance of complete installation records.

9.7 Field Inspection

The Bidder shall permit Employer to perform inspections of the assembly which will include a complete verification of the assembly of all parts as to their levels, clearances, pertinent fits, alignments and quality of workmanship. The field supervisor of the Bidder shall provide Employer with three (3) copies of all the clearances, tolerances and data of all pertinent fits, alignments and levels, so that the latter may repeat the Bidder's measurement, if desired.

Unless otherwise specified, any rejection based on the inspection will be reported to Bidder within fifteen (15) days and injurious defects subsequent to assembly and acceptance will be rejected.

10 INSPECTIONS AND TESTS

10.1 General

In addition to the provisions established in the Conditions of Contract regarding general procedure of inspections and tests, terms and definitions, and time schedules for inspections and tests the following stipulations shall apply.

Approval of assemblies, tests, inspections, related procedures etc. and acceptance of pertinent test and inspection certificates, or waiving of inspections or tests, shall in no way relieve the Contractor of his contractual obligations for finishing the Works in accordance with the provisions of the Specifications.

Three (3) sets of all test records, test certificates, performance curves, tables etc. of all inspections and tests, whether or not attended by the Engineer shall be supplied soonest after performance of each inspection or test. After completion of all testing three (3) sets of the above-mentioned documents shall be supplied properly bound in books.

All test certificates shall be endorsed with sufficient information for identification of the equipment and material to which the certificates refer.

The raw material tests for special works such as special casting/ forging shall also be offered for inspection by Owner.

In addition, the following references shall be entered in the top right-hand corner:

i) Employer's name,
ii) Project title,
iii) Plant's name,
iv) Number of Contractor's drawing,
v) Date.

10.2 Workshop Inspections and Tests

As far as practicable, quality of materials, workmanship and performance of all items of the Works to be furnished under this Contract shall be inspected at the places of manufacture.

The contractor shall offer inspection of raw materials by employer for specific works such as casting/forging and same shall be specified in the Quality Assurance Plan to be submitted for employer's approval.

Where the Contractor desires to use stock material, not manufactured specifically for the Works, satisfactory evidence that such material conforms to the requirements of the Contract shall be submitted.

Arrangements shall be made for expediting the shop inspection by having all shop assemblies or pieces covering a single shipment ready at one time. Any painting work as well as transport to the site of the Works shall not be started before the approval of the Engineer has been obtained.

Free and unrestricted access to the Contractor's factory and shops (including those of his Sub-Contractors) shall be granted to the Engineer also and upon reasonable notice by the Engineer if deemed necessary by the same for additional witnessing of assembly work or inspections and tests.

Should an agreed inspection not be carried out as proposed because of lack of preparation, obvious negligence or material and/or equipment being presented in a state, which not corresponds to the proposed procedure or is clearly not acceptable such an inspection shall be repeated. The cost incurred by the Employer for repeated inspections shall be fully borne by the Contractor.

10.2.1 Material Tests

Unless otherwise specified, the quality of materials shall be verified generally by:

i) Chemical analysis,
ii) Mechanical tests (yield point, tensile strength, elongation, and notch impact.),
iii) Welding tests (welding procedure, welding material, welding tensile strength, welding bend test, welding reversed bend test, etc.),
iv) Non-destructive x-rays, ultrasonic, magnaflux, liquid tests, penetration inspection, etc.),
v) Electrical tests (voltage, losses, tan delta, insulation, magnetic properties etc.),
vi) Certified mill test reports of plates will be acceptable when these comply with the requirement of specifications. Test specimen and samples for analysis shall be plainly marked to indicate the materials they represent.

Castings and forgings shall be tested in the rough state in order to detect flaws in good time thus avoiding delays. Magnetic particle inspection of important castings shall cover the whole surface of the casting. After partial machining, further tests can be conducted.

Load tests on crane hooks, steel wire ropes, chains and other lifting devices, etc. shall be considered as material tests.

10.2.2 Checking of Dimensions

The dimensions, especially clearances and fits, (ISO 286) which are essential for operation and efficiency shall be carefully checked in an approved manner, as for example:

i) Run out and roundness tolerances of shafts, pistons, etc., to be measured on single parts as well as (wherever possible) on the assembled components,
ii) Fits and clearances of bearings, servomotor pistons, valves, guiding, distributing and actual actuating elements, etc.,
iii) Accuracy, surface roughness and shape of sliding and guiding surfaces of seals, bearings, water passages in hydraulic machinery, valves, etc.,

iv) Dimensions of couplings or connections for assembly with other deliveries from the Contractor, Sub-Contractors or other Contractors.

10.2.3 Workshop Assembly

In addition to the quality and production control tests, the following shop assembly work and tests shall be made to check measurements, fitting and functioning:

i) Works to be furnished shall be shop assembled to a status sufficient to prove that the design and workmanship have been executed in accordance with the Specifications, that the delivery is complete, and that no work remains to be done at Site, which reasonably can or should be done in the shop,

ii) Where applicable, each item of the Works shall be assembled completely prior to painting,

iii) Field joints shall be temporarily connected,

iv) All parts shall be properly match marked, identified and doweled where practicable, to facilitate correct and quick field assembly and alignment,

v) Where necessary, suitable dowels shall be provided for insertion after field assembly and drilling. The holes for any fitted bolt shall be accurately reamed,

vi) During workshop assembly all instruments, control devices and piping shall be fitted,

vii) If the assembly shows defects in the design or manufacture or unforeseen difficulties in assembling and dismantling, these shall be eliminated. If required, design alterations or corrective measures can be executed provided that reliability of operation or interchangeability is not reduced and provided that the agreement of the Engineer has been obtained,

viii) If the corrections cannot be carried out in accordance with the terms mentioned above, the components concerned will be rejected. The decision on possible subsequent corrections is reserved exclusively to the Engineer. Faulty parts or Works shall by no means be delivered/ used at site,

ix) The assembled parts shall subsequently be subject to tests as per applicable standards or required by the Engineer.

10.2.4 Pressure and Leakage Tests

All parts subject to internal or external pressure or containing any liquids or gases temporarily or permanently during operation shall be tested prior to painting. As far as practicable, these tests shall be done in the shop but can be repeated at site.

Parts exposed during operation to hydraulic pressure, to gas pressure or to any liquid without pressure, shall be treated distinctively.

In addition to the Specifications, the applicable and approved standards and official regulations shall be observed. If any liquid is used for the test that may cause corrosion, all Works and piping shall be thoroughly cleaned immediately after the test.

As far as practicable and required, the influences of temperatures and temperature differences to which the part will be exposed during operation shall be considered in the execution of the tests.

Leaks and defects can be repaired if permitted by the applicable standards and approved by the Engineer. If defects are found, the Engineer may reject the defective parts, or permit welding repairs with stress relieving, radiographic examination and additional pressure tests.

Parts Exposed to Hydraulic Pressure:

Unless otherwise specified or required, the following shall apply: the hydraulic pressure tests shall be carried out using the liquid to be used during operation or a liquid with less viscosity.

The hydraulic test pressure shall be l.5 times the maximum operating pressure (except for spiral distributor) and shall be maintained for a period of eight hours or longer if required by the applicable standards. Afterwards the test pressure shall be reduced to the operating pressure.

The welded seams of large parts, which are not subjected to any heat treatment during or after welding, shall be rapped with a 500 g hammer during the pressure decrease or treated otherwise to obtain the required effect of stress relief.

Finally, the test pressure mentioned above shall be maintained for ten (10) minutes. Leakages appearing at seals, joints, etc. shall be measured and stated in the test report, together with the relevant pressures.

Parts Exposed to Gas Pressure:

Parts which will be subjected to gas pressure during operation for example pressure tanks, pressure air tanks and others, shall be inspected and tested according to the official regulations with respect to design, construction, fittings, etc.

The pressure test shall be executed by applying the test pressure in accordance with the relevant standards and specifications.

Parts Exposed to Liquids without Overpressure:

Parts which shall not be closed and which are exposed to only small pressures of any liquid during operation e.g., bearing housings, oil containers, etc.) shall be subjected to a tightness test with a suitable liquid of low viscosity. The testing-period shall not be less than 8 hours, unless otherwise agreed.

10.2.5 Functional Tests

Functional tests shall be defined as tests of the function of assemblies, sub-assemblies or parts of the Works under no load conditions. Functional tests shall be performed on all Works prior to the execution of operational tests.

10.2.6 Operational Tests

As far as practicable operational test shall be carried out on all Works, simulating operating conditions.

Parts to be delivered by sub suppliers shall be tested either at the premises of the sub supplier or of the Contractor, as agreed by the Engineer.

Before testing the Contractor shall submit a notice containing full information on the tests with detailed tables or graphs on the latest edition of the characteristic values of the Works to be tested and on the test facilities and equipment.

Testing of the electrical Works shall be performed in accordance with applicable Standards; they shall include but not be limited to tests of heating, loading, overloading, losses.

Operational tests of lifting equipment and other machinery shall include tests under nominal load and 125 % of nominal load unless otherwise specified.

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10.2.7 Electric Tests

Electrical Works shall be tested in accordance with applicable Standards and agreed test programs and procedures.

10.2.8 Model Tests

Model tests for certain parts of the work or Works shall be carried out as specified or agreed between Contractor and Engineer.

10.2.9 Witnessing of Workshop Tests

Employer shall depute engineers for inspection of parts/component/systems covered under package in the shop from time to time in accordance with the manufacturing schedule and particularly the customer Hold Points (CHP) of approved Quality Assurance Plan.

In each case of witnessing of test, the Bidder shall furnish, well in advance, all the relevant drawings and documents including test proforma indicating all the elements to be tested during the witnessing, procedures to be followed and designed values, reference of standard and permissible tolerances for on the spot comparison to tested values.

The Bidder shall declare readiness of material and equipment for testing well in advance. Notice of inspection shall be given to purchaser/consultant minimum 1 month prior to the date of testing. Such tests shall be to the Bidder's account and all the expenses relating to or connected with the tests are deemed to have been included in contract price. Purchaser or his representatives shall attend such tests at the time so notified unless inspection is waived–off by the purchaser in writing. Bidder shall forthwith forward to the purchaser/consultants duly certified copies of test reports in quadruplicate.

When the factory tests have been completed at the Bidder's works and the tests witnessed by the purchaser, the purchaser shall issue a certificate to this effect within 15 days after completion of tests. If the tests are not witnessed by the purchaser, the tests reports submitted by the Bidder to the purchaser shall require purchaser's approval/comments. If the purchaser fails to communicate his approval/comments. If the purchaser fails to communicate his approval/comments within 60 days of receipt of test report, the report shall be deemed to have been approved by the purchaser and failure of the purchaser to issue such a certificate shall not prevent the Bidder to continue with the next stage of manufacturing/dispatch. The completion of these tests, or the issue of the certificate shall not bind the purchaser to accept the equipment should it, on the future tests after erection, be found not to comply with the contract specification.

The purchaser shall within sixty days from the date of inspection, give notice in writing to the bidder of any objection to any test report and or drawings and or any equipment and workmanship which in his opinion is not in accordance with the contract. The Bidder shall give due consideration to such objections and shall make the modification that may be necessary to meet the said objections and shall submit a report to the purchaser.

Should any inspected or tested goods fail to conform to the specification, the purchaser may reject them and the Bidder shall either replace the rejected goods or make all alterations necessary, with the consent of purchaser, to meet the requirements of technical specification free of cost to the purchaser. No extension in the delivery period shall be given on this account.

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The purchaser's right to inspect, test and, where necessary, reject the goods after arrival in the purchaser's country shall in no way be limited or waived by reason of the goods have previously been inspected, tested and passed by the purchaser or his representative prior to the dispatch from the country of origin.

10.3 Site Inspection and Tests

During erection, commissioning and trial operation, the Contractor shall perform at suitable intervals all inspections and tests in the presence of the Engineer in order to prove the orderly execution of the works in accordance with the Contract.

Unless otherwise specified, all costs for testing at site and of the works and charges associated with it shall be borne by the Contractor. This includes the measuring devices, properly calibrated, and any pertinent accessories, which shall be made available by the Contractor for the entire duration of the tests. The Contractor shall delegate his experts to perform the tests at site.

The Engineer reserves the right to have checked at his own expenses the Contractor's instruments to be used or having been used for any tests by an independent, officially acknowledged institution.

Special tests to be performed at Site are listed in the corresponding chapter of the Particular Technical Specifications.

The Contractor's testing at Site shall be complete in every respect to prove the successful performance and operation of all the works and Works supplied and erected under the Contract.

In case of disagreement between the Engineer and Contractor(s) on the test results, an independent expert shall be appointed by Employer to whom both parties shall agree. If no amicable settlement can be reached, the Arbitration Clause shall be applied.

For the procedure of inspections and test at site, notice to the Engineer, reports, commissioning, trial runs and trial operation, and acceptance tests refer to General Conditions of Contract.

10.3.1 Commissioning and Trial Operation

Immediately upon completion of commissioning of a part or section of the Permanent Works, which can operate as an independent unit a "Certificate of Suitability for Operation", shall be issued by the Engineer.

This document shall be signed by an authorized representative of the Employer, the Engineer and the Contractor.

This Certificate shall state:

i) The supplier of the Works concerned,
ii) The quantity and type of Works concerned,
iii) The conditions of commissioning,
iv) The names of the participants,
v) The date of commencement of trial operation,
vi) The list of minor defects, if any, which has to be corrected by the Contractor.

During the trial operation the Contractor shall make familiar the Employer's personnel with the equipment, the operation and maintenance of the Works and its auxiliaries to such extent that thereafter the duties can be assigned to the Employer's trained personnel.

If any defects or irregularities affecting the safety or reliability of the Works should arise during the trial operation the trial operation shall be interrupted and started again after such defects or irregularities have been corrected by the Contractor.

10.3.2 Performance Test

If nothing unusual has been observed in load run and load rejection tests, the trial run operation period of 72 hours shall follow. During this trial run operation period, the unit must operate continuously at rated condition without any interruption except of those beyond the control of the Contractor. However, such interrupted period shall not be counted for in the trial run operation period.

The Contractor shall be responsible for the equipment during trial run operation period and also for the way it is operated. However, Employer's personnel will operate the equipment under the Contractor's guidance during trial run operation.

10.3.3 Acceptance

The taking-over testing of any part or section of the Permanent Works which can operate as an independent unit, shall be performed in accordance with the standards and regulations laid down in the " General Conditions of Contract", and as per the test procedure agreed upon between Engineer and Contractor.

Immediately upon completion of any such testing of a part or section of the permanent Works a "Protocol of Acceptance" which shall be deemed to be the Test Certificate required by General Conditions of Contract shall be issued by the Engineer.

This document shall be signed by an authorized representative of the Employer, the Engineer and the Contractor and shall form an integral part of the later "Taking-Over Certificate".

This "Protocol of Acceptance" shall state:

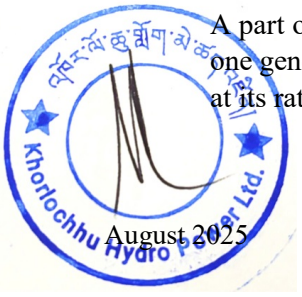
i) The date of testing,
ii) The quantity and type of Works concerned,
iii) Statement of all minor defects and/or irregularities, which have to be corrected by the Contractor,
iv) Confirmation that the guaranteed data have been proven,
v) Confirmation that all contractual documents have been submitted,
vi) Confirmation that the Employer's personnel have been familiarized with the Works and that they will be able to operate and maintain the Works.

If any test for the verification of the guaranteed data could not be performed for operational reasons beyond the Contractor's responsibility, this part of the acceptance shall be stated in the "Protocol of Acceptance" and be postponed for a mutually agreed period.

However, the tested part or section of permanent work shall continue to be operated by the Contractor, with the help of Employer's personnel, till all generating units have been tested and commissioned.

Note:

A part or section of the permanent works shall for the purpose of this contract means one generating unit with all its units and station auxiliaries required to operate the unit at its rated load.



10.3.4 Performance Guarantee

The Bidder shall guarantee that the equipment offered shall meet the ratings and performance requirements stipulated for various equipment/systems covered in these specifications and in Guaranteed Technical Particulars.

The Bidder shall demonstrate all the guarantees covered herein during functional guarantee/acceptance tests.

11 TRAINING OF EMPLOYER'S PERSONNEL

The Bidder shall arrange training to familiarize the employer's personnel about constructional and O&M aspects of equipment wherever need of specialized training is felt during detail engineering. Cost of such training shall be borne by the Bidder. Travelling and living expenses of the personnel deputed on such training, however, shall be borne by the Employer.

Besides above, the Bidder shall hold training sessions to familiarize the Employer's personnel with all aspects of operation and maintenance of the plant and sub-systems before the beginning of the dry tests on site. The technical documentation used in the training sessions shall include the Bidder's draft operation and maintenance manuals and test procedure descriptions approved by the Employer. The Bidder shall provide training for each phase of work as per details agreed at the time of award.

11.1 General Requirements of Training

The Bidder shall provide suitable instructors, training material and facilities (instruments, apparatus, simulators, documents, drawings, protective clothing, rooms, office supplies, etc.) for the personnel made available by the Employer for training.

One month before the training start, the Employer will send the list of the trainees and any comments on the training program proposed by the Bidder. This program shall be adapted to the design and nature of the Works, and the needs of trainees. Trainees shall be suitably trained in the various aspects of design, manufacture, installation/erection, operation and maintenance, relevant to the training, of works similar to the Works

The Bidder shall supervise and provide direction to, and be liable for the acts or omissions, other than negligent or willful misconduct of such personnel, of the Employer's trainees.

The Bidder shall provide the training described hereafter in accordance with any further specific requirements stated in the Employer's Requirements.

The Bidder shall assist the Employer in obtaining any visas and other formalities for entering or leaving the territory on which the training is being provided.

The Bidder shall bear responsibility for ensuring the safety of the trainees during their stay in the country of the training. On their part, the trainees shall comply with the laws, regulations and customs of the country in which training is being provided.

In the event of illness or accident, the Bidder shall take all steps to provide the trainees with the appropriate medical care.

11.2 Training during Engineering/Manufacturing Phase

This shall cover all disciplines viz, Mechanical, Electrical, C&M & QA etc. and shall include all the related areas like design familiarization, training on product design features and product design software of major equipment and systems, engineering,

manufacturing, erection, commissioning, training on operating features of equipment, quality assurance and testing, plant visits and visits to manufacturer's works, exposure to various kinds of problems which may be encountered in fabrication, manufacturing, erection, welding etc. The training in areas of Operation and Maintenance shall take place preferably during end of manufacture/ tests.

The proposed training for various equipment and systems shall be minimum 60 man-months (Actual training excluding rest days/holidays).

11.3 Training during Erection/Installation/Testing & Commissioning

Independently from the supervision and inspection functions of the Employer's Representative, the Bidder shall authorize the Employer's Personnel to follow the erection/installation/testing & commissioning and site work at his site.

The Employer's Start-up Personnel shall take no part in the equipment erection and/or installation operations, which shall be exclusively carried out by the Bidder and under his entire responsibility.

This onsite training shall cover each phase of erection/installation/testing & commissioning and shall be of sufficient duration.

The Bidder shall supply the information or measurements concerning the erection requested by the Employer's Representative or/and by the Employer's personnel. The Bidder shall also provide on the-job training in the operation and maintenance of the Works to the Employer's Operating Personnel. Such training shall start at least 30 days prior to commencement of Tests on Completion and continue until Taking Over. Its scope and quality shall be such as to provide the trainees with comprehensive understanding of all operational and maintenance aspects of the work. Such training shall also include safety and environmental protection aspects applicable to the work. The proposed training for various equipment and systems shall be minimum 16 man-months.

12 QUALITY CONTROL AND ASSURANCE

12.1 Quality Assurance Plan

To ensure that the equipment under the scope of this contract whether manufactured or performed within the supplier's works or at his sub-supplier's premises or at the employer's site or at any other place of work are in accordance with the specifications, the supplier shall adopt suitable quality assurance program to control such activities at all points. Such programs shall be outlined by the supplier before the award of contract and shall be only accepted by the employer after discussions of contract. The applicable IS or ISO Standard or equivalent standard adopted by the supplier or certification obtained by the supplier/manufacturer along with its validity period shall be stated in the bid

An outline description of the Quality Assurance Program to be used by the Bidders shall be included in its Bid. A quality assurance program of Bidder shall generally cover relevant details of the following:

i) Its organization structure for the management and implementation of the proposed quality assurance program,

ii) Engineering operation as per ISO 9000 with design planning, design reviews with Engineer, Design verification, validation,

iii) Site erection procedures by designers,

iv) Qualification and experience data of supplier's key personnel,

v) Documentation control system,

vi) The procedure for purchasing of materials, parts, components and selecting of Sub-Contractor's Services including vendor analysis, source inspection, incoming raw material inspection/verification of materials purchased etc,

vii) System for identification and traceability of parts/components/products/instruments/ control devices,

viii) System for shop manufacturing and site erection controls including process controls, fabrication and assembly controls,

ix) Control of non-conforming items and system for objective actions,

x) Realization, Inspection and test procedures both for manufacture and field activities,

xi) Control of calibration for testing and measuring equipment,

xii) System for indication and appraisal of inspection status,

xiii) System for handling, storage, packaging, transportation and delivery at site,

xiv) System for quality audits,

xv) System for Maintenance of quality records,

xvi) System for authorizing release of the manufactured product to the Employer.

The Contractor shall submit the detailed Quality Assurance Plan (QAP) for the complete equipment/materials during detailed engineering for approval and acceptance by the Employer in line with the requirement of model QAP. The approved QAP shall form integral part of the contract.

12.2 Quality Assurance Test and Inspection

The QAP shall include inspection and tests proposed to be conducted on raw material/bought out items at the time of induction in the process of manufacturing and at final stage of assembly. These shall include but not limited to the following:

i) Material test of raw material,

ii) Non-destructive examination as approved by employer,

iii) Component Inspection and tests,

iv) Assembly Inspection and tests:

a) Pressure test / high voltage dielectric and other test,

b) Operational tests,

v) Performance and efficiency tests as applicable,

The Shop Assembly Test, Type/Routine Tests and Acceptance tests shall be witnessed by the representative of Employer as per requirement of approved Quality Assurance Plan and Contractor shall proceed for next stage of manufacturing after clearance/approval of previous stage of manufacturing.

After carrying out pre-dispatch inspection/tests satisfactorily, formal dispatch clearance/authorization for shipment shall be issued.

The Bidder shall also furnish copies of the reference documents/plant standards/acceptance norms/test and inspection procedures etc. as referred in quality plans. These quality plans/reference documents/standards etc. will be subject to approval without which manufacturer shall not proceed. KHPL reserves the right to add any inspection or test which is felt necessary as endorsement for qualitative completion of the work. These approved documents shall form a part of the contract. In these approved quality plans, KHPL shall identify customer hold points (CHP's) i.e. test checks which shall be carried out in the presence of the authorized

representative of the employer/consultant and beyond which the work will not proceed without the consent of KHPL/authorized representative in writing. All deviations to these specifications, approved quality plans and applicable standards must be documented and referred to KHPL alongwith technical justification for approval.

The Bidder shall furnish field quality plans which will detail out the quality practices & procedures etc. for all the equipment to be followed by the Bidder's site quality control organization during various stages of site activities from receipt of material/equipment at site. The field quality plans shall also be approved by the KHPL.

12.3 Quality Assurance Documents

The supplier shall be required to submit the following applicable Quality Assurance Documents prior to dispatch of the equipment:

i) All procedures pertaining to non-destructive examination, stress relieving and repairing of weld actually used during fabrication,

ii) Qualifications and experience certificates of Welders and welding operators,

iii) Welder identification list, indicating the qualifications and experience of Welders and welding operators and welding identification symbols,

iv) Material test reports on components as specified by the specifications,

v) The inspection plan alongwith its checkpoints, verification sketches used if any alongwith the methods used to verify that the inspection and testing were carried out satisfactorily,

vi) Sketches and drawings used for indicating the method of traceability of the radiographs to the location on the equipment,

vii) Reports & results of non-destructive examination including reports for radiography interpretation,

viii) Stress relief time temperature charts,

ix) Test reports for the tests carried out at the works as per applicable codes and standards referred in the specification,

x) Inspection reports duly signed by Quality Assurance Personnel of the employer and supplier for the agreed inspection hold points. During the course of inspection, the following shall also be recorded:

   a) Any important repair work carried out or to be carried out to make the job acceptable,

   b) The repair work remains part of the accepted product quality,

The Contractor shall also furnish the field quality manuals for various field activities detailing the procedures and inspection check lists for transportation, storage/preservation, erection, pre-commissioning and commissioning activities. The field quality manuals shall indicate the various assembly/erection/operation tolerances and limits of deviations for each individual equipment and system.

Owner reserves the right to carry out quality audit and quality surveillance of the system and procedures. However, such audit or quality surveillance by Owner shall not relieve Contractor of any of its responsibilities under the terms of Contract.

No material shall be dispatched from the manufacturer's works before the same is accepted prior to pre-dispatch/final inspection including verification of records of all previous tests/inspection by KHPL's/their authorized representative duly authorized for dispatch.

All the vendors/sub-vendors proposed by the Bidder for procurement of major bought out items including castings, forgings, semi-finished and finished components/equipment, list of which shall be drawn up by the Bidder and finalized/approved in consultation with KHPL. The Bidder's proposal shall include vendor/sub-vendor's facilities established at the respective works, the process capability, process stabilization, Q.C. system followed, experience list etc. along with their own technical evaluation of vendor/sub-vendors and shall be submitted to the owner for approval prior to any procurement. The approval for such vendor/sub-vendor shall not relieve the Bidder from any obligation, duty or responsibility under the contract. This action shall, however, not involve KHPL in any complications arising between the Bidder and his sub-bidder(s)/vendor/sub-vendors from whom he proposes to procure the material and submit their quality plans for KHPL's approval.

Bidder shall supply main equipment/system strictly out of the list of manufacturers attached in the bid document. Normally no request for change of sub-vendors shall be entertained by KHPL. But in the peculiar circumstances if the request for change of sub-vendors is found reasonable and justified then the same shall be entertained and the decision of KHPL in this respect shall be final and binding. The time consumed for the change of sub-vendors shall not be excluded from the stipulated time of the completion of the contract. This change shall not relieve the Bidder from the responsibility to complete the work within stipulated time in any manner.

Important tests/inspections shall be subject to witness by the owner for which the supplier shall give sufficient advance notice. In case owner is unable to witness shop tests/inspections, the supplier shall be so intimated and the tests/inspections may then be carried out in the absence of the owner.

Equipment on which tests and inspections have been duly witnessed and approved by the owner may be dispatched by the supplier.

Equipment on which tests and inspections have not been witnessed by the owner shall be dispatched only after the shop tests and inspection certificates have been got approved from the owner.

The supplier shall furnish five (5) copies of shop tests and inspection certificates to the owner.

12.4 ISO certification

In case the Contractor or his sub-contractor/vendor does not possess ISO-9000 series certification, he shall submit following details during detailed engineering for assessment of his capacity to supply quality equipment/materials/services under the contract:

i) Contractor's quality system details,
ii) Details of system for dealing with items not conforming to prescribed specification,
iii) Details of stage and final inspection and auditing,
iv) Contractor's system for calibration of testing and measuring equipment,
v) Details of testing and measuring equipment available with Contractor,
vi) Details of important facility/equipment available with Contractor to produce reliable products having requisite standard,
vii) Qualification and experience of Contractor's key QA personnel.

13 PRIORITY OF DCUMENTS

The documents forming the Technical Specifications are to be taken as mutually explanatory of one another. If there is an ambiguity or discrepancy in the documents, the Employer shall issue necessary clarification or instruction to the Bidder and the priority of the documents shall be as follows:

i) Particular Technical Specification of each equipment in the respective packages,
ii) Guaranteed Technical Particulars in Data Sheets,
iii) General Technical Specification,
iv) In case of dispute in interpretation, Employer's interpretation shall be final and binding.

14 UNIT MODEL

A scaled 3D model of section through a unit depicting the details of turbine generator set as closely as possible shall be supplied by the Bidder.

The model should have high quality of craftsmanship to ensure the inclusion of all major details of the unit set. The components used shall be easily detachable and assemble back to model for demonstration and in-house training purpose. The details of model may be discussed during detailed engineering and should be approved by the Employer before acceptance of the same.

15 TECHNICAL DATA SHEETS

Bidder shall furnish guaranteed & other technical particulars of the offered equipment in the data sheets given in Volume:6 Data Sheets. Figures which are guarantee figure as per the technical data sheet & as per particular technical specification shall be guaranteed by the bidder.

16 SCHEDULE OF DEVIATION

Any technical deviation sought by the bidder shall be brought to the notice of the employer in clear written form duly justifying the same.

17 SOFTWARE

The Bidder shall furnish latest network version of software used for designing, commissioning & operation of the supplied equipment with minimum 6 (six) users' licenses. All software shall be of latest version. Regular up-gradation/updation of all the supplied software during contract period including extension if any shall be included in the scope.

Latest 3-D software shall also be supplied by main plant supplier for reviewing and detail workout of overall plant layout by Engineer.

18 COMPLETENESS OF SYSTEM/EQUIPMENT/ITEMS

The works to be carried out as per the scope defined in respective sections shall be all in accordance with the requirements, conditions, appendices etc. given in Technical Specifications (GTS, PTS, Data Sheets and Tender Drawings) together with those stated in General Conditions of Contract (GCC) and Particular Condition of Contract (PCC).

It is not the intent to specify herein all aspects of design and construction; nevertheless, the equipment and installation/works shall conform in all aspects to high standard of engineering, design and workmanship and shall be capable of performing in continuous commercial operation in a manner acceptable to the Employer, who will

interpret the meaning of the specification and drawings and shall have a right to reject or accept any work or material which in his assessment is not complete to meet the requirements of this specification and/or applicable Indian / International standards mentioned elsewhere in this specification.

Any such system/equipment/items, which are not explicitly mentioned in specification but are functionally necessary/advisable as per best national/international practices for smooth operation of powerhouse, shall be deemed to be included in the scope of work and the Contractor shall provide the same without any extra cost to Employer.



ANNEXURE-I PAINTING SYSTEM

Type	Description	Surface Preparation	Paint System	Main Dry Film Thickness in µm	Remark
1	Un-machined internal surfaces of indoor ferrous parts in water contact such as distributors, pit liners, turbine housing, runner head cover, main inlet valves including other wetted internal ferrous surfaces of turbine.	Sa 2 1/2-3	Prime Coat: 1x zinc dust primer, 2-component Base: epoxy resin	1x50	
			Intermediate Coat: 1x coal tar epoxy, 2-components	1x125	The colours of intermediate and finish coats shall be black -brown-black
			Finish Coat:1x Coal tar epoxy, 2-components	1x125	
			Total	**300**	
2	External surfaces of Cranes, Lifting Beams, Fixed Hoist, and other similar Drive Supports	Sa21/2-3	Prime Coat: 1x zinc dust primer, 2-component Base: epoxy resin	1x50	The pure metallic zinc shall be at least 92% of the polymerized film
			Intermediate Coat:2x micaceous iron oxide paint, 2-component Base: epoxy resin	2x80	This paint system is for temperatures up to 600 C
			Finish Coat: 1 x micaceous iron oxide paint, coloured, 2-component Base: epoxy resin	1x80	
			Total	**290**	
3	Un-machined external surfaces of indoor ferrous parts which are directly exposed to air such distributors, pit liners, turbine housing, runner head cover, bearing supports & housing, pit	Sa21/2-3	Prime coat : 1 x zinc dust primer, 2-component Base: epoxy resin	1x50	The pure metallic zinc shall be at least 92% of the polymerized film
			Intermediate Coat :	2x75	

Type	Description	Surface Preparation	Paint System	Main Dry Film Thickness in µm	Remark
	liner, regulating ring, servomotors, accumulator, main inlet valves, connection pipes, oil/air tanks, lower & upper bracket, stator frame, including other similar items.		2 x micaceous iron oxide paint, 2- component Base: epoxy resin		This paint system is for temperatures up to 1200 C
			Finish Coat : 1 x topcoat, 2-component Base: epoxy resin	1x50	
			Total	**250**	
4	Control panels/cubicles, switch gear panels and other panels/cubicles except marshalling kiosks etc.	Sa21/2-3 and de- grease before painting or any other equivalent process.	Prime coat: All enclosures, frames, bottom cover etc., should be dip coat primed or zinc plated and passivated for corrosion resistance or equivalent.	20-25	Finally to be approved at design stage
			Finish Coat; Texture powder coating or equivalent as per approved color code on interior and exterior surface	>70	
			Total	**>95**	
5	Interior surfaces of oil and air tanks such as bearing oil tank, accumulator, sump tank, air tank and other similar items	Sa21/2–3	Prime coat: 1x epoxy iron oxide or equivalent	50	
			Finish Coat : 1 x polyurethane or equivalent	75	
			Total	**125**	

ANNEXURE-II STANDARD PAINTING SCHEDULE/ COLOUR GUIDELINES

Sl. No.	Equipment	Colour	Ref. Colour
1	Turbine casing	Silicon Grey	RAL 7032
2	Main Inlet Valve	Mint Green	RAL 6029
3	Governors	Silicon Grey	RAL 7032
4	Governor Cubicle	Pearl White	RAL 1013
5	LCC for Governor/MIV OPU	Pearl White	RAL 1013
6	Oil Sump Tank	Grey	RAL 7035
7	Oil Pressure Tank	Orange	RAL 2000
8	Generator Top Cover	Pearl White	RAL 1013
9	LAVT/NGT/Transformers	Grey	RAL 7035
10	Bus Duct	Grey	RAL 7035
11	Brake Dust Collector	Grey	RAL 7035
12	Braking Air Tank/Control Cubicle	Grey	RAL 7035
13	HS Oil Unit	Grey	RAL 7035
14	EOT Crane	Yellow	RAL 1004
15	EOT Crane Power Supply Box	Pearl White	RAL 1013
16	Cooling Water Pump, Filters, Cyclone separators etc.	Mint Green	RAL 6029
17	LCC for Cooling Water System	Pearl White	RAL 1013
18	Heat Exchanger	Mint Green	RAL 6029
19	HP Compressed air system Compressor/Dryer/Tank	Sky Blue	RAL 5015
20	Oil purifying system (Tank, Pumps etc.)	Orange	RAL 2000
21	LCC for Drainage & Dewatering	Pearl White	RAL 1013
22	Oil Pressure Piping	Yellow Orange	RAL 2000
23	Oil Purification Piping	Yellow Orange	RAL 2000
24	Oil Purification System	Yellow Orange	RAL 2000
25	Air Piping	Light Blue	RAL 5012
26	Water Piping	Green	RAL 6029
27	Enclosures for electrical power equipment	Melon Yellow	RAL 1029
28	Enclosure for electrical control and protection equipment	Light Grey	RAL 7035
29	Switchyard structure	Galvanized	

Note:- Colours mentioned above shall be finally agreed upon during detail design. The colour code for equipment not listed in the above mentioned specifications shall be agreed upon after the award of the Contract. The colouring of pipelines, moving parts, etc., shall be according to internationally recognized standards.

ANNEXURE- III: PETROGRAPHY TEST REPORT

PETROGRAPHY TEST REPORT

Table No. 1 (Sample No. KSD7a)

Mineralogical composition (in %) of sediments of suspended material

S.No.	Grain Size (μ)	Quartz/Lithic fragments (H*=7) (Sp**2.65)	Feldspar (H*=6-6.5) (Sp**2.57-2.76)	Magnetite (H*=5.5-6.5) (Sp**5.16-5.18)	Hornblende (H*=5.5) (Sp**3.05-3.47)	Biotite/ Muscovite (H*=2-4) (Sp**2.7-3.0)
1	-250	78-80	4-5	3-4	2-3	10-11
2.	+125	77-78	6-7	4-5	Nil	10-12

Table No. 2 (Sample No. KSD7b)

Mineralogical composition (in %) of sediments of suspended material

S.No.	Grain Size (μ)	Quartz/Lithic fragments (H*=7) (Sp**2.65)	Feldspar (H*=6-6.5) (Sp**2.57-2.76)	Magnetite (H*=5.5-6.5) (Sp**5.16-5.18)	Hornblende (H*=5.5) (Sp**3.05-3.47)	Biotite/ Muscovite (H*=2-3) (Sp**2.7-3.0)
1.	-250	75-77	8-10	3-4	2-3	8-10
2.	+125	73-74	6-8	4-6	4-5	9-11

H*: Hardness
Sp** Specific gravity

ANNEXURE-IV REQUIRED DOCUMENTS FOR E&M EQUIPMENT

1. General

In compliance with clause 2 of GTP, the following documents for the E&M Equipment shall be supplied to the Employer. For identical items being supplied several times such documents shall be submitted once only.

2. Principal Requirements

The following documents shall be supplied individually or as a whole for equipment/installations wherever applicable.

i) **Loading Drawings**

As per General Technical Specification, Volume- 4, clause 2.2.1

ii) **Foundation Drawings**

As per General Technical Specification, Volume- 4, clause 2.2.2

iii) **Arrangement Drawings**

For the whole plant and for individual areas/buildings /rooms/trenches as per General Technical Specification, Volume- 4, clause 2.2.3

iv) **Colour Schedule**

As per General Technical Specification, Volume- 4, clause 4.7

3. Specific Documents for all Equipment as Applicable

Sl. No.	DOCUMENTS FOR ALL EQUIPMENT AS APPLICABLE
1	Shop test programs
2	Material test certificates
3	Shop test reports
4	Welding procedures
5	Welder's qualification certificates
6	Paint Schedules
7	Material specification
8	Instruments List
9	Commissioning Program
10	Wiring diagrams
11	Program for testing of Employer's personnel
12	Trial operation Program
13	Emergency shutdown procedures
	TURBINE AND ACCESSORIES
1	Specification and Technical Data
2	Design Memorandum
3	Model Test Report
4	Turbine – Master Shipping List
5	Turbine - Loads on Foundation and its Calculation
6	Turbine - Foundation Drawings
7	Foundation Details – Concrete Sequence and Lifts
8	Foundation Details of auxiliaries as per applicability
9	Hydraulic Transient Analysis, Pressure Rise, Speed Rise& GD2 Calculation
10	Runner FEM calculation and its natural frequency

11	Turbine – general layout
12	Turbine –sections (D/T to coupling)
13	Turbine- control gear diagram
14	Turbine -component list
15	Turbine – outline drawings
16	Turbine embedded Pipes-GA
17	Erection Manual part I (embedded parts) & Erection inspection sheets (embedded parts)
18	General Arrangement of Distributor
19	Arrangement of Central Framework
20	Installation of Lower Pit Liner
21	Embedded Tubes for Field Efficiency Test
22	Installation of Distributor
23	Installation of Turbine Housing
24	1st Stage Foundation and Cut-outs
25	2nd Stage Foundation and Cut-outs
26	1st Stage Pipes and Embedment
27	2nd Stage Pipes and Embedment
28	Decompression Valve
29	Arrangement of Nozzle with Servomotor
30	Servomotor calculation – stress analysis and selection
31	Storage Manual (to be submitted to site for approval)
32	Arrangement of Deflector Mechanism
33	Brake Jet Assembly
34	Deflector Servomotor Arrangement
35	Arrangement. of Runner
36	General Arrangement of Shaft
37	Machining of Turbine Shaft
38	Turbine shaft & coupling bolt – stress Analysis and critical speed
39	Guide Bearing – Arrangement
40	Guide bearing calculation- Stress analysis
41	Guide bearing - Assembly Drawing
42	Guide bearing – Segment – Machining (Section, Plan, TSD/RTD hole, Babbitt thickness etc.)
43	Heat exchanger/temperature rise calculation for turbine guide bearing
44	Pressure Testing Devices (for Distributor)
45	Tools, Tackles and Erection devices
46	Tools, Tackles and Erection devices (For Nozzle)
47	Tools, Tackles and Erection devices (For Runner)
48	Oil Pipelines
49	Pipes in Turbine Pit
50	Rating Plate for Turbine
51	Turbine - Painting Specification
52	Turbine – Material Specification
53	Shaft Calculation
54	Distributor Calculation
55	Runner Calculation

56	Lower Pit Liner Calculation
57	Arrangement of Lower Pit Liner
58	Lower Pit Liner Welded Assembly
59	Calculation of Turbine Housing
60	Design Memorandum for Main Injector with Needle
61	Calculation for Main Injector with Needle
62	Distributor – Cross section GA
63	Distributor – Component drawing
64	Distributor Segment- 1 with Inlet Flange
65	Distributor Segment- 2
66	Distributor Segment- 3
67	Distributor Segment- 4
68	Distributor Segment- 5
69	Turbine Housing Outer Lower Segment
70	Turbine Housing Outer Upper
71	Turbine Housing Inner Part
72	Arrangement for Guide Bearing Handling
73	Design Memorandum on Decompression valve
74	Design Memorandum on Brake Jet Valve
75	Railing in Turbine pit
76	Calculation of Deflector Servomotor
77	Design Memorandum on Deflector Servomotor & A Mechanism
78	Calculation of Guide Bearing
79	Design Memorandum of embedded Tubes for head measurement for field efficiency test
80	Bearing safety devices arrangement
81	Guide bearing dismantling arrangement
82	Turbine and Generator shaft assembly
83	Runner – GA
84	Runner - machining details
85	Runner -welding details (if applicable)
86	Runner - handling/dismantling
87	Runner- turbine shaft - coupling arrangement
88	Over speed device
89	Vibration monitoring system - GA
90	Ultrasonic flow measurement system
91	Silt measuring system
92	Instrumentation List
93	Erection Manual Part II (Turbine) & Erection Inspection A Sheets (Turbine)
94	List of Spares
95	List of Tool and Tackles (inclusive of those required for erection and dismantling/handling)
96	Site Test Schedule & Procedures (based on the approval of design wing)
97	Site Test Document & Procedures (to be submitted to site for approval)
98	Commissioning Procedures & Record Document
99	O&M Manual
100	Field Efficiency Test Procedure & Field Efficiency Record Document

101	Other drawings/documents as required by employer, timed during detailed engineering
	DIGITAL GOVERNOR SYSTEM AND ACCESSORIES
1	Design Memorandum
2	Governing system Calculation note
3	Design Calculation of OPAU
4	Design calculation of receiver
5	Design calculation of sump
6	Design calculation of pumps
7	Governing system Functional diagram
8	Governor - general arrangement drawings
9	Foundation details – OPU & Sump
10	Foundation details - HMC
11	Foundation details - EMC
12	Governing system - Pressure tank - General
13	Governing system - Sump tank - General layout
14	Piping - General Layout
15	Turbine instrument & Monitoring diagram
16	Governor - Inputs and Outputs List
17	Governor –feedback mechanism
18	Storage Manual (to be submitted to site for approval)
19	Governing system - Pressure tank - Wiring & terminal box
20	Governing system - Sump tank - Wiring & terminal box
21	Governor - Cubicle Wiring
22	Governor - Operating Instructions
23	Schematic diagram for electro hydraulic governor controller
24	Specification of instruments and devices for OPU system
25	Speed Signal Generator & Over Speed - General
26	Arrangement of PLC and other modules
27	Internal logic diagram of PLC module
28	Erection Manual & Erection inspection sheets
29	List of spares
30	List of tool and tackles (inclusive of those required for erection and dismantling/handling)
31	Site test Schedule & procedures (based on the approval of design wing)
32	Site test document & procedures (to be submitted to site for approval)
33	Commissioning procedures & record document (dry & wet test)
34	O&M manual
35	Other drawings/documents as required by employer, time during detailed engineering
	MAIN INLET VALVE AND ACCESSORIES
1	Design Memorandum
2	MIV –master shipping list
3	Loads on foundation - Calculation note
4	Main inlet valve – Stress calculation of valve bodies, disc, lever etc.
5	Main inlet valve – Counterweights sizing
6	Main inlet valve - Servomotor sizing and its stress analysis

7	Stress analysis Calculation- Upstream and downstream sleeve/ pipe
8	Main inlet valve - OPU system calculation and sizing
9	Main inlet valve – design calculation of sump
10	Main inlet valve – design calculation of receiver
11	Main inlet valve – design calculation of pump
12	Main inlet valve - Bypass valve sizing
13	Material Specification (MIV)
14	Painting (as per clause 3.0 of GTS)
15	Loads On Concrete - Drawing
16	Foundation-First Stage Concrete Drawing
17	Foundation-Second Stage Concrete Drawing
18	Foundation details – OPU & Sump
19	Erection Manual part - I (embedded parts) & Erection inspection sheets
20	Storage Manual (to be submitted to site for approval
21	General Arrangement - MIV, Upstream sleeve & Downstream sleeve
22	Arrangement of Servomotor
23	Arrangement of Bypass Valve
24	Valve body- GA
25	Valve disk – GA
26	Valve seal – GA
27	MIV – welding details
28	Downstream sleeve – GA
29	Upstream sleeve – GA
30	Counterweight- General assembly
31	Counterweight – arrangement and detail
32	Oil Pipelines – General arrangement and clamp details
33	Service and Maintenance seal – G.A.
34	MIV – Functional/ Hydraulic diagram
35	Inlet valve - Pressure tank - General layout
36	Inlet valve - Sump tank - General layout
37	Inlet valve - Pressure tank - Wiring & terminal
38	Inlet valve - Sump tank - Wiring & terminal
39	Procedure for MIV seal
40	Schematic diagram for control and indication
41	Specification of instruments and devices for OPU system
42	MIV – Control panel/Terminal blocks – GA
43	Erection Manual part - II (MIV) & Erection inspection sheets
44	List of spares of MIV
45	List of tool and tackles (inclusive of those required for erection and dismantling/handling)
46	Site test Schedule & procedures (based on the approval of design wing)
47	Site test document & procedures (to be submitted to site for approval)
48	Commissioning procedures & record document (dry & wet test)
49	O&M manual
50	Other drawings/documents as required by employer, time to time during detailed engineering
	BUTTERFLY VALVE AND ACCESSORIES

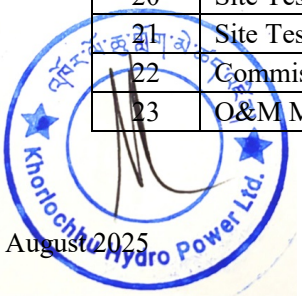
1	Design Memorandum
2	Butterfly Valve –master shipping list
3	Loads on foundation - Calculation note
4	Butterfly Valve – Stress calculation of valve bodies, disc, lever etc.
5	Butterfly Valve – Counterweights sizing
6	Butterfly Valve - Servomotor sizing and its stress analysis
7	Stress analysis Calculation- Upstream and downstream sleeve/ pipe
8	Butterfly Valve - OPU system calculation and sizing
9	Butterfly Valve – design calculation of sump
10	Butterfly Valve – design calculation of receiver
11	Butterfly Valve – design calculation of pump
12	Butterfly Valve - Bypass valve sizing
13	Material Specification (MIV
14	Painting (as per clause 3.0)
15	Loads On Concrete - Drawing
16	Foundation-First Stage Concrete Drawing
17	Foundation-Second Stage Concrete Drawing
18	Foundation details – OPU & Sump
19	Erection Manual part - I (embedded parts) & Erection inspection sheets
20	Storage Manual (to be submitted to site for approval)
21	General Arrangement - Butterfly Valve, Upstream sleeve
22	Arrangement of Servomotor
23	Arrangement of Bypass Valve
24	Valve body- GA
25	Valve disk – GA
26	Valve seal - GA
27	Butterfly Valve – welding details
28	Downstream sleeve – GA.
29	Upstream sleeve – GA
30	Counterweight- General assembly
31	Counterweight – arrangement and detail
32	Oil Pipelines – General arrangement and clamp details
33	Service and Maintenance seal – GA
34	Butterfly Valve – Functional/ Hydraulic
35	Butterfly Valve - Pressure tank - General
36	Butterfly Valve - Sump tank - General layout
37	Butterfly Valve - Pressure tank - Wiring & terminal box
38	Butterfly Valve - Sump tank - Wiring & terminal box
39	Procedure for Butterfly Valve seal engagement/disengagement
40	Schematic diagram for control and indication panel
41	Specification of instruments and devices for OPU system
42	Butterfly Valve–Control panel/Terminal blocks–GA
43	Erection Manual part-II (Butterfly Valve) & Erection inspection sheets
44	List of spares of Butterfly Valve
45	List of tool and tackles (inclusive of those required for erection and dismantling/handling)
46	Site test Schedule & procedures (based on the approval of design wing)

47	Site test document & procedures (to be submitted to site for approval)
48	Commissioning procedures & record document (dry & wet test)
49	O&M manual
50	Other drawings/documents as required by employer, time to time during detailed engineering
	GENERATOR
1	Specification and technical data
2	Design memorandum
3	Generator – master shipping list
4	Loading on foundation - Calculation
5	Loading on service bay
6	Calculation for bottom bracket and stator
7	Stator frame calculation
8	Upper bracket calculation
9	Lower bracket calculation
10	UGB calculation
11	LGB calculation
12	Thrust bearing calculation
13	Shaft calculation
14	Rotor rim calculation
15	Rotor spider calculation
16	Pole calculation
17	Critical speed and runaway speed calculation
18	Calculation of strength of all rotating parts to withstand run away speed and vibration
19	Calculation of all coolers for stators and all bearings, the A normal working pressure and pressure drop through the coolers
20	GD2 calculation
21	Coupling bolt size calculation
22	Electrical calculations and characteristics including magnetic circuit
23	Calculation to substantiate capability of generator to withstand the additional stresses resulting from operation of unit with three adjacent guide vane passage in blocked condition
24	Size of the thrust bearing, effective surface area/specific load under worst condition/runaway condition
25	Maximum stress/load during normal operation/runaway operation and other electrical fault and magnetic unbalance condition
26	Temperature rise calculation of guide bearing coolers and stator air coolers
27	Calculation of ventilation of generator
28	Calculation of size and no. of brake/jack assemblies
29	Calculation of NGT and resistor
30	Generator – materials (refer clause 3.0)
31	Generator – paintings (refer clause 3.0)
32	Generator - Foundation drawing
33	Foundation details – Lower bracket
34	Foundation details – Stator
35	Foundation details – Upper bracket
36	Foundation details – Radial jacks

37	Foundation details – other auxiliaries as per applicability
38	Arrangement of Bottom bracket sole plates
39	Arrangement of stator sole plates
40	Generator- outline and lifting arrangement
41	Generator –sectional arrangement (coupling to top)
42	Machine – sectional arrangement (D/T to top)
43	Generator – cooling water piping arrangement
44	Generator – stator winding development
45	Generator – slot layout
46	Generator – component list
47	Erection Manual part I (embedded parts) & Erection inspection sheets (embedded
48	Storage Manual (to be submitted to site for approval)
49	Stator frame –GA and component drawing & core assembly
50	Wound stator
51	Stator lifting arrangement
52	Air coolers - GA
53	Air cooler installation and air duct cover
54	Rotor rim assembly – GA and component
55	Rotor spider
56	Rotor assembly
57	Wound pole arrangement
58	Pole fixing arrangement
59	Pole lifting arrangement
60	Shaft - GA & component drawing
61	Shaft - machining
62	Lifting and turning of shaft
63	Coupling bolt/nut/stud - details
64	Coupling bush or key – details as per applicability
65	Shaft and spider fixing
66	Arrangement of brake track segment and spider
67	Slip ring covering
68	Collector assembly
69	Arrangement of rotor lead assembly (pole to spider)
70	Arrangement of rotor lead assembly (shaft to collector)
71	Arrangement of fan (top and bottom)
72	Rotor lifting arrangement
73	Thrust collar and runner disc (with ins) Assembly
74	Thrust collar - machining
75	Runner disc - machining
76	Top shaft and thrust collar arrangement
77	Top shaft, thrust collar & Regulating disc ins. Assembly and lineout
78	Lifting arrangement for thrust collar and runner disc
79	Fixing of nut guard
80	Arrangement of thrust bearing
81	Thrust bearing – Component drawing
82	Thrust bearing - segment – machining (section, plan, TSD/RTD hole, Babbitt thickness etc.)

83	Arrangement of thrust pad removal
84	Line and neutral terminal arrangement
85	Generator – auxiliary connection
86	HS lubrication system and arrangement of its piping
87	Top bracket centre and arm assembly
88	Arrangement of radial jacks
89	Arrangement of DC connection and brush
90	Arrangement of air and oil vapour piping
91	Arrangement of Upper guide bearing
92	Upper guide bearing – component drawing
93	UGB - segment – machining (section, plan, TSD/RTD, hole Babbit Thickness etc.)
94	UGB handling
95	Lower Guide bearing arrangement
96	Lower guide bearing–component drawing
97	LGB -segment –machining (section, plan, TSD/RTD hole, babbit thickness etc.)
98	LGB handling
99	Oil cooler (bottom)
100	Oil cooler (top)
101	Arrangement of bottom oil cooler withdrawal and cover
102	Bottom bracket lifting arrangement
103	Top bracket lifting arrangement
104	Brake and Jack system–arrangement of brake piping and conduit
105	Arrangement of pit air seal
106	Arrangement of carbon dust collector
107	Arrangement of space heater
108	Cooling water pipes inside barrel
109	Top and bottom air guide fixing arrangement
110	Shaft current monitor system
111	Online PDA system
112	Online Vibration monitoring system
113	Bearing safety devices arrangement
114	Arrangement of stator instruments
115	Instrumentation list
116	Firefighting system arrangement
117	Erection Manual part II (Generator) & Erection inspection sheets (Generator)
118	List of spares
119	List of tool and tackles (inclusive of those required for erection and dismantling/handling
120	Site test Schedule & procedures (based on the approval of Site test Schedule & procedures (based on the approval of design wing)
121	Site test document & procedures (to be submitted to site for approval
122	Commissioning procedures & record document (dry & wet test)
123	O&M manual
124	Field efficiency test procedure & Field efficiency record
125	Other drawings/documents as required by employer, time other drawings/documents as required by employer, time

	STATIC EXCITATION SYSTEM
1	Design Memorandum
2	Design Calculation for the Capacity of Thyristor Bridges, A DC Breaker, AC Breakers, Discharge Resistor, etc.
3	Foundation Plan for Static Excitation equipment
4	Overall G.A. for static excitation equipment
5	Equip/comp. Details and specification for static excitation
6	Schematic diagram, Electrical circuit and control drawings
7	Internal logic diagram of PLC module
8	Technical data sheet - Excitation Transformer
9	GA of Excitation Transformer
10	Erection Manual & Erection inspection sheets
11	Storage Manual (to be submitted to site for approval)
12	List of spares
13	List of tool and tackles (inclusive of those required for erection and dismantling/handling
14	Site test Schedule & procedures (based on the approval of design wing)
15	Site test document & procedures (to be submitted to site for approval)
16	Commissioning procedures & record document (dry & wet test)
17	O&M manual
18	Other drawings/documents as required by employer, time to time during detailed engineering
	BUS DUCT
1	Design Memorandum
2	Temperature Rise Calculation used for Sizing of Bus-duct
3	Load Calculation for Supporting Structure
4	Calculation in regard of rating of NG transformer and Resistor
5	Calculation verifying the burden and knee point voltage in resects of CT's
6	Layout of Isolated (IP) Bus duct
7	Foundation Layout - IP Bus duct
8	SLD - IP Bus duct
9	Technical data sheet
10	G.A of LAVT Cubicle
11	Wiring diagram of LAVT cubicle
12	GA of NGT cubicle
13	Wiring diagram of NG cubicle
14	CT wiring diagram
15	Arrangement of ventilation for Bus duct system
16	Erection Manual & Erection Inspection sheets
17	Storage Manual (to be submitted to site for approval)
18	List of Spares
19	List of tool and tackles (inclusive of those required for erection and dismantling/handling
20	Site Test Schedule & Procedures (based on the approval of design wing)
21	Site Test Document & Procedures (to be submitted to site for approval)
22	Commissioning Procedures & Record Document
23	O&M Manual



24	Other drawings/documents as required by employer, time to time during detailed engineering
	ELECTRICAL OVERHEAD TRAVELLING CRANES
1	Design memorandum
2	Crane load data
3	EOT crane- Rails & civil work guide drawing
4	EOT crane- Design Calculation of structural parts and mechanisms
5	EOT crane- Technical specifications
6	EOT crane- General sizing drawing
7	EOT crane- General Arrangement drawings
8	EOT crane- Wheel machinery drawings
9	EOT crane- Wheel assembly drawings
10	EOT crane- Gear box drawings
11	EOT crane- Girder drawings
12	EOT crane- Snatch block drawings
13	EOT crane- Crab drawings
14	EOT crane- Rope drums drawings
15	EOT crane- Main Hook/ Auxiliary hook drawings
16	EOT crane- Electrical diagrams
17	EOT Crane – Wiring diagram
18	DSL connection drawing of EOT crane
19	Erection Manual & Erection inspection sheets
20	Storage Manual (to be submitted to site for approval)
21	List of spares
22	List of tool and tackles (inclusive of those required for erection and dismantling/handling)
23	Site test Schedule & procedures (based on the approval of design wing)
24	Site test document & procedures (to be submitted to site for approval)
25	Commissioning procedures & record document
26	O&M manual
27	Other drawings/documents as required by employer, time to time during detailed engineering
	COOLING WATER SYSTEM
1	Design Memorandum
2	Capacity Calculation for Cooling Water System/ equipment
3	Cooling water system – pump sizing calculation
4	Schematic flow diagram/ Diagram of control gear for Cooling water system
5	Layout arrangement of cooling water system
6	Technical specification of equipment for cooling water A system – pumps, filters, heat exchangers, cyclone separators, valves and instrumentations etc.
7	Cooling water system – operation and control philosophy
8	Pumps – GA & Cross section
9	Heat exchangers - GA & Cross section
10	Cyclone separators - GA & Cross section
11	Automatic Strainers - GA & Cross section
12	Valves - GA & Cross section
13	Specification of instruments & devices for cooling water system

14	Piping routing drawings
15	Piping isometric drawings
16	Pipe support details
17	Storage Manual (to be submitted to site for approval)
18	List of spares
19	List of tool and tackles (inclusive of those required for erection and dismantling/handling)
20	Site test Schedule & procedures (based on the approval of design wing)
21	Site test document & procedures (to be submitted to site for approval)
22	Commissioning procedures & record document (dry & wet test)
23	O&M manual
24	Other drawings/documents as required by employer, time to time during detailed engineering
	DRAINAGE AND DEWATERING SYSTEM
1	Design Memorandum
2	Pump and Pipe Sizing calculation
3	Flow diagram /Diagram of Control Gear of Drainage and A Dewatering System
4	GA & cross section – Pumps and valves
5	Operation and control philosophy
6	Sump Cover - details
7	Technical specification/ drawing of equipment/ instruments and devices
8	Electrical drawings
9	Storage Manual (to be submitted to site for approval)
10	List of spares
11	List of tool and tackles (inclusive of those required for erection and dismantling/handling)
12	Site test Schedule & procedures (based on the approval of design wing)
13	Site test document & procedures (to be submitted to site for approval)
14	Commissioning procedures & record document
15	O&M manual
16	Other drawings/documents as required by employer, time to time during detailed engineering
	GROUNDING SYSTEM
1	Design memorandum
2	Soil resistivity measurement report
3	Powerhouse underground earth mat design
4	Powerhouse underground earth mat layout
5	Technical data sheet grounding materials
6	Grounding network – GA drawings.
7	S/Y earthing
8	Buried electrodes - erection drawings
9	Electrodes and main network principle diagram
10	Electrodes and main network sizing calculation
11	Equipment grounding list
12	Out of soil network erection drawings
13	List of tool and tackles (inclusive of those required for erection and dismantling/handling)

14	Site test Schedule & procedures (based on the approval of design wing)
15	Site test document & procedures (to be submitted to site for approval)
16	Other drawings/documents as required by employer, time to time during detailed engineering
	COMPRESED AIR SYSTEM
1	Design memorandum
2	Capacity calculation and selection of air compressor, dryer and receiver
3	Stress calculation of LP air receiver
4	LP compressed air flow diagram
5	Operation and control philosophy
6	G A of air compressor
7	G A of air pressure tanks
8	G A of air dryer
9	Cross section and part detail of air compressor
10	Technical specification of air compressor, air dryer and air receiver
11	Piping layout
12	Piping – isometric view
13	Specification of instruments & devices for compressed air system
14	Equipment drawings
15	Electrical diagrams
16	Storage Manual (to be submitted to site for approval)
17	List of spares
18	List of tool and tackles (inclusive of those required for erection and dismantling/handling)
19	Site test Schedule & procedures (based on the approval of design wing)
20	Site test document & procedures (to be submitted to site for approval)
21	Site test document & procedures (to be submitted to site for approval)
22	O&M manual
23	Other drawings/documents as required by employer, time to time during detailed
	HEATING VENTILATIONS & AIR CONDITIONING (HVAC) SYSTEM
1	Design memorandum
2	Sizing calculation
3	Flow diagram
4	G.A. for HVAC System for the Plant
6	G.A. of AHU's, Fresh Air Units, Exhaust Air Units & etc.
7	GA– Chiller Units, Pumps & Filters
8	Technical specification/ Drawing of the equipment, instrument and devices of HVAC system
9	Equipment drawings
10	Storage Manual (to be submitted to site for approval)
11	List of spares
12	List of tool and tackles (inclusive of those required for erection and dismantling/handling)
13	Site test Schedule & procedures (based on the approval of design wing)
14	Site test document & procedures (to be submitted to site for approval)
15	Commissioning procedures & record document
16	O&M manual

17	Other drawings/documents as required by employer, time to time during detailed engineering
	LUBRICATING OIL SYSTEM
1	Design memorandum
2	Sizing calculation
3	Flow diagram
4	G.A. for lubricating oil filtration plant
5	G.A. for transformer oil filtration plant
6	G.A. of lubricating oil tank
7	GA–Transformer oil filtration tank
8	Technical specification/ Drawing of the equipment, instrument and devices of oil filtration system
9	Equipment drawings
10	Storage Manual (to be submitted to site for approval)
11	List of spares
12	List of tool and tackles (inclusive of those required for erection and dismantling/handling)
13	Site test Schedule & procedures (based on the approval of design wing)
14	Site test document & procedures (to be submitted to site for approval)
15	Commissioning procedures & record document
16	O&M manual
17	Other drawings/documents as required by employer, time to time during detailed engineering
	FIRE PROTECTION SYSTEM
1	Design memorandum
2	Sizing calculation
3	Flow diagram
4	G.A. for Fire Protection System for plant
5	G.A. for Detection & Alarm plant
6	BoQ of the Fire Protection & Detection System
7	GA–Annunciation Panel
8	Technical specification/ Drawing of the equipment, instrument and devices of oil filtration system
9	Equipment drawings
10	Storage Manual (to be submitted to site for approval)
11	List of spares
12	List of tool and tackles (inclusive of those required for erection and dismantling/handling)
13	Site test Schedule & procedures (based on the approval of design wing)
14	Site test document & procedures (to be submitted to site for approval)
15	Commissioning procedures & record document
16	O&M manual
17	Other drawings/documents as required by employer, time to time during detailed engineering

KHORLOCHHU HYDRO POWER LIMITED

4x150 MW KHORLOCHHU HYDROPOWER PROJECT

TRASHIYANGTSE; BHUTAN



BIDDING DOCUMENT

FOR

CONTRACT PACKAGE: KEM-1

DESIGN, MANUFACTURING, SUPPLY, INSTALLATION, TESTING AND COMMISSIONING OF ELECTRO-MECHANICAL WORKS

VOLUME - 4

EMPLOYER'S REQUIREMENTS

PARTICULAR TECHNICAL SPECIFICATIONS (PTS)

International Competitive Bidding

These documents are meant for the exclusive purpose of bidding against this NIT and shall not be transferred, reproduced or otherwise used for purposes other than that for which they are specifically issued.

Tender Ref. No. KHPL/C&PD/TENDER:KEM-1/2025/11534 dt. 07.08.2025

LAYOUT OF BIDDING DOCUMENTS

CONTRACT PACKAGE: KEM - 1

Design, Manufacturing, Supply, Installation, Testing and Commissioning of Electro-Mechanical Works

Volume - 1: Instructions to Bidders (ITB)

- Section - 1 Abridged Notice Inviting Tender and Notice Inviting Tender (NIT)
- Section - 2 Instructions to Bidders (ITB), Bid Data, Qualification Forms, Information for Bidders (IFB) and Work Schedule

Volume - 2: General Conditions of Contract (GCC) and Particular Conditions of Contract (PCC)

- Section - 3 FIDIC General Conditions of Contract (GCC) for Plant and Design-Build Contract (First Edition 1999)
- Section - 4 Particular Conditions of Contract (PCC) and Appendix to Tender
- Section - 5 Forms and Procedures
  - Form-1: Letter of Tender
  - Form-2: Form of Contract Agreement
  - Form-3: Bank Guarantee Form for Performance Security
  - Form-4: Bank Guarantee Form for Advance Payment
  - Form-5: Form of Taking Over Certificate
  - Form-6: Bank Guarantee Form for Release of Retention Money
  - Form-7: Hindrance Register
  - Form-8: Dispute Adjudication Agreement
  - Form-9: Parent/Holding Company Agreement
  - Form-10: Proforma for Joint Deed of Undertaking

Volume-3: Price Schedules

Volume-4: Employer's Requirements

- Section - 6 General Technical Specifications (GTS)
- Section - 7 Particular Technical Specifications (PTS)
- Section - 8 Quality Assurance Plan (QAP)

Volume-5: Tender Drawings

Volume-6: Technical Data Sheets



SECTION -7

PARTICULAR TECHNICAL SPECIFICATIONS

(PTS)



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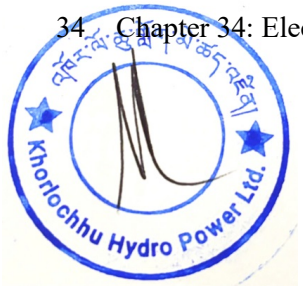

CHAPTER 1: TURBINE AND ACCESSORIES

1.1 Scope of Work

Scope of work under this section covers the provision of labor, tools, plants, materials and performance of work necessary for the design, model testing, manufacture, quality assurance, quality control, shop assembly, shop testing, delivery at site, site storage and preservation, insurance, installation, commissioning, performance testing, acceptance testing, training of Employer's personnel, handing over to Employer and guarantee for three years of four (4) sets of vertical shaft Pelton Turbines as per the specifications hereunder, each complete with all auxiliaries, accessories, spare parts and warranting a trouble free safe operation of the installation. The Systems shall be suitable for Ambient, Seismic, Altitude and other site conditions mentioned in General Technical Specification.

The scope of work shall be a comprehensive functional system covering all supply and services including, but not limited to, the following:

1.1.1 Turbine and Accessories

i) Four (4) sets of six jet (6) vertical shaft Pelton Turbines each with rated output of not less than 152.3 MW at design head of 761.53 meters with nozzle opening not more than 85%, shall be complete and comprising of following main components:

   a) Fixed/embedded components including turbine housing assembly, spiral distributor, embedded piping and foundation parts,

   b) Six jet nozzles each with needle servomotor, six jet deflector each with one deflector servomotor,

   c) Turbine guide bearing.

   d) Rotating components including Runner, turbine shaft and nut guard assembly etc.,

   e) Runner/turbine shaft and turbine shaft/generator shaft coupling bolt,

   f) Four (4) sets of pit liners,

ii) Four (4) sets of brake jet assembly.

iii) Four (4) sets of service platform/central framework assembly including rails for runner inspection/removal platform.

iv) One (1) sets Runner removal trolley.

v) Four (4) sets of anchors, turn-buckles, fixtures, machine pads, base plates, jacks and foundation bolts, rails etc.

vi) Four (4) sets of Turbine pit monorail hoists, platforms, walkways, handrails, stairs, cover plates, access doors, acoustic barriers, floor gratings / hatch cover on all floor opening for runner handling etc.

vii) Four (4) sets of necessary fittings/piping/accessories etc.

viii) Hydraulic Transient Analysis, Pressure Rise, Speed Rise& GD2.

ix) Four (4) sets of advanced ultrasonic or any other suitable continuous on-line flow measurement system along with required numbers of transducers/ sensors and associated accessories for measuring, monitoring and data acquisition and integration of the system with plant SCADA system.

x) Four (4) sets of fixed type online and one (1) set of portable optical type silt measuring instruments to indicate and record the silt content of the water passing through the turbine.

xi) All other necessary items / equipment / provision for synchronous condenser mode operation.

xii) Four (4) sets of all necessary control, monitoring, safety and metering instruments/devices/system including interfacing with plant SCADA.

xiii) Two (2) sets of handling devices/slings etc. for runner, nozzles and for dismantling of underwater components from below.

xiv) Two (2) sets of runner inspection platform sectionalized into components including scaffolding for easy handling.

xv) Four (4) lot of Turbine oil, first filling of all components with 10% extra quantity, in non-returnable drums, for all four (4) units.

xvi) Spare parts in accordance to clause 1.13 "Spare Parts" of this section.

xvii) Tools and Tackles in accordance to clause 1.15 "Tools and Instruments" of this section.

xviii) One (1) lot of power, control & special cables and cable glands, lugs, terminals, connectors etc. for cabling of equipment and devices covered in this chapter.

Any other item(s) not mentioned specifically but necessary for the satisfactory completion of scope of work defined above, as per accepted standard(s)/best international practices.

1.2 Specific Design and Layout Conditions

1.2.1 Water Conductor System

The main components of water conductor system are as follows:

i) Power Intake

a) Invert Level : EL 1546.00 m, 2 numbers and 56.4 m3/sec each

ii) Head race tunnel

b) Numbers, diameter & shape : 1 number, 5.7m diameter & Horse shoe

c) Discharge capacity : 89 m^3 /sec

d) Length of Tunnel : 16.30km

iii) Surge shaft

a) Numbers, diameter & Height : 1 no., 9.5m diameter & 162.80m height

b) Type : Open to sky with Restricted orifice

iv) Pressure Shafts

a) Numbers, diameter & shape : 2 numbers, 3.3 m diameter & circular

b) Type : Steel lined

c) Length : 1534.74m each

v) Penstock

a) Numbers diameter & shape : 4 numbers, 2.35 m diameter & circular

b) Type : Steel lined

c) Length : 187m

vi) Tailrace Tunnel

a) Number, Diameter & Shape : 1 number, 6m (w) x 6m (h), D – shape

b) Length of tunnel : 1591 m

c) Unit : 4 numbers, 3.5m(W) X 6m(H), D-Shape, 605.19m long

1.2.2 Hydraulic Conditions

The hydraulic conditions under which the turbine shall be operated are given below:

i) Full Reservoir Level (FRL) : EL 1572 M

ii)	Minimum Draw Down Level	: EL 1558 M
iii)	Average Reservoir level	: EL 1567.33 M
iv)	PMF level at TRT outfall	: EL 761.5 M
v)	Maximum Tail Water level at P.H end	: EL 768 M
vi)	Maximum Head Loss in water conductor system	: 33.33 m
vii)	Centerline of the Runner	: EL 772.50
viii)	Operating conditions during monsoon season & peaking in other season.	:Continuous Operation
ix)	Operating range of net heads	
	a) Design Head (Weighted Average Net Head)	: 761.5 m
	b) Maximum Net Head	: 766.2 m
	c) Minimum Net Head	: 752.2 m

1.2.3 Design Considerations

1.2.3.1 Power House Layout

The project is envisaged as an underground powerhouse having four vertical shaft generating units, each comprising of a pelton turbine directly coupled to a synchronous generator. Layout of powerhouse and general arrangement of generating units and other equipment, details of water conductor system have been outlined in the layout drawings. The center line of the turbine has been fixed at EL. 772.5 m corresponding to highest tail water level at EL.768.0 m i.e. 4.5 m above maximum tail water level at Powerhouse end. The Contractor shall ensure that runner is not submerged in froth/ water over the entire operating range, including up to 110% load on all machines simultaneously, and with maximum tail water level of 768.0 m with available free board for water flow.

1.2.3.2 Assembly and Disassembly

Turbine may require frequent disassembly for repair. The Contractor shall design the turbine such that disassembly and assembly of runner, nozzle and deflector etc. can be done from below the turbine without disturbing the generator components.

The runner, nozzle and deflectors are envisaged to be carried to service bay through a hatch in between two units. The hatch is dedicated for two units. The runner, after dismantling from the turbine shaft, shall be lowered and clamped on the runner-handling cart for which suitable arrangement shall be provided. The runner-handling cart shall be taken out from runner removal hatch and runner shall be lifted by the powerhouse EOT crane and be taken to service bay at EL 784.0 M. Other turbine components shall also be handled through the cart.

1.2.3.3 Special Design Considerations

The turbine shall be designed to provide the following:

i) Turbine generator unit shall be designed to provide Output of not less than 152.3 MW (150 MW at generator terminals) in the entire operating head range including minimum head.

ii) Turbine generator unit shall be designed for a rated output of not less than 150 MW at generator terminals when operated at a design head of 761.5 m within 85% nozzle opening.

iii) Turbine generator unit shall also be capable of delivering 110% continuous rated output at design head of 761.5 m with less than 90% nozzle opening.

iv) The turbine shall be designed for direct coupling to 150 MW, 0.90 power factor, 50 ± 5% Hz, 375 rpm synchronous vertical shaft generator,

v) Machine should be designed such that, machine should deliver the rated power output at Maximum & Minimum range of voltage & frequency variation range.

vi) Turbine generator unit shall be designed to operate satisfactorily without undue vibration and noise in the range from 110% - 6% of rated output of 150 MW at generator terminals.

vii) Turbine generator unit shall be designed for 5 start & 5 stops per day.

viii) Bidder to program the governor such that the deflector position shall be set (close to jet) with respect to position of needle (jet diameter) and shall act immediately on load throw-off without delay

ix) Bidder to design the turbine generator unit considering same grade of oil for turbine OPU, MIV OPU, BFV OPU, Lube oil, and any other oil used in the plant.

x) Nozzle servomotor shall be arranged inside turbine pit assembly,

xi) Servicing and removal of runner, nozzles and deflectors shall be through the runner removal gallery then to hatch provided in between two units,

xii) The turbine guide bearing lubricating oil and governor oil shall be of the same specification as the generator bearing oil,

xiii) The weight of all rotating parts and any unbalanced vertical hydraulic thrust shall be supported by the generator thrust bearing,

xiv) The turbine shaft and bearing shall be designed to operate under any combination of needle openings/unbalanced condition,

xv) The turbine bearing support shall be designed to support the weight of the turbine rotating parts when the turbine shaft is uncoupled from the generator shaft,

xvi) Means shall be provided which will permit selection of the number of nozzles in operation,

xvii) Selection of number of nozzles shall be automatic self-selection type on part load. Provision for operation of different nozzle(s) for better efficiencies, along with auto-changeover facility, shall be made,

xviii) For part load operation, for better efficiency and when one or two nozzles are out of service, the remaining nozzles shall still be properly governed,

xix) All equipment shall be neatly arranged in the turbine pit in such a way that will facilitate easy operation and maintenance,

xx) Inertia constant of generating unit at maximum output shall be indicated in the bid. The flywheel effect (GD2) of the generating unit shall be worked out accordingly by manufacturer to contain speed rise and pressure rise within limits,

xxi) The turbine shall be designed suitably for automated and continuous operation of the units in Synchronous Condenser Mode of Operation also. All the turbines shall be provided with necessary arrangements such as cooling arrangements for runner & seals, water drainage & air release arrangements, piping arrangements etc., so that the units can be operated hassle free in synchronous condenser mode continuously.

1.2.3.4 Noise and Vibration Limit

Turbine design shall be such as would ensure smooth and quite operation with low vibrations, pressure pulsations, power fluctuations and noise. The vibration amplitude at the shaft shall not exceed the values specified in ISO-7919 (part 1) and ISO-3945.

Contractors shall guarantee that the detrimental pulsations (both for Pressure and Power) do not occur at any load and during transients i.e. at steady condition from 6% (Six) load to 110% (Maximum) load of the generator.

The maximum noise level, including transient conditions (Start, load rejection or surge), at a place 1m distance from turbine shaft shall not exceed 85 dB, and the same shall be guaranteed

and proved at site by actual measurement. Design provision made for achieving these guarantees shall be elaborated during design stage.

1.2.3.5 Silt Erosion Considerations and Petrographic Analysis

The project is situated in Himalayan region where the silt content during high flow period is excessive and peaks abnormally during high flood. Turbine may be expected to operate continuously under silt concentration of more than 3000 ppm during high flood. Petrography test report is attached as **Annexure-III of Generated Technical Specification.**

The Contractor shall critically study the silt data of water and take the same into account in designing the turbine and auxiliary equipment susceptible to abrasive effect of silt and making all such specific provisions so as to minimize the effect of silt.

1.2.4 Construction Methodology

The EOT crane columns are envisaged to be concreted after second stage concreting in sub-structure and raft at MIV floor. However, prior to concreting of EOT crane columns, the crane beam on the rock ledge shall be provided by the civil contractor which shall be capable of taking loads of 35T. E&M Contractor as per his requirement, if need be, may provide a temporary EOT Crane or any other alternative of suitable capacity (not more than 35T) on rock ledge.

Such temporary EOT crane/arrangement shall remain the property of E&M contractor and shall be dismantled after the availability of main EOT cranes in all the units. No additional cost shall be paid to the E&M contractor for providing the above.

1.3 Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable International Standards / Indian Standards (IS) as given below except where modified and/or supplemented by this specification.

Sl. No.	Description	Standards
1	Hydraulic turbines, storage pumps and pump-turbines – Model acceptance tests.	IEC 60193
2	Cavitation's pitting evaluation in hydraulic turbines, storage pumps and pump turbines.	IEC 60609
3	Field acceptance tests to determine the hydraulic performance of hydraulic turbines, storage pumps and pump- turbines.	IEC 60041
4	Hydraulic Turbine – testing of control system.	IEC 60308
5	Guide for commissioning, operation and maintenance of hydraulic turbines.	IEC 60545
6	Guide for field measurement of vibrations and pulsations in hydraulic machines (Turbine, storage pumps and pump turbines).	IEC 60994
7	Determination of the prototype performance from model acceptance tests of hydraulic machines with the consideration of scale effects.	IEC 60995
8	Guide to specification of hydraulic turbine control system.	IEC 61362
9	Mechanical vibration – Evaluation of machine vibration by measurements on rotating shafts - machine sets in hydraulic power generating and pumping plants.	ISO 7919 part-5
10	Mechanical vibration – Balance quality requirements for rotors in a constant (rigid) state – part -1: Specification and verification of balance tolerances.	ISO 1940 - 1
11	Mechanical vibration – evaluation of machine vibration by measurements on non-rotating parts – Machine sets in hydraulic power generating and pumping plants.	ISO 10816 – 5

Sl. No.	Description	Standards
12	IEEE standard for hydraulic turbine and generator integrally forged shaft coupling and shaft run out tolerances.	IEEE - 810
13	Specification for shock and vibration measurements; characteristic to be specified for seismic pick-ups.	BS 7119
14	Specification for inspection of steel castings for hydraulic machines.	CCH 70 – 3

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted subject to approval of the Employer. In such case, copies of the English version of the standards adopted shall have to be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules, Central Electrical Authority's rules and regulation as amended up to date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.4 Rating and Functional Characteristics

1.4.1 Turbine Rating

Each turbine shall be designed for a rated output of not less than 150 MW at generator terminals and at rated speed of 375 rpm when operated at a design head of 761.5 m within 85% nozzle opening. It shall also be capable of delivering 110% continuous rated output at design head and less than 95% nozzle opening. The center line of the turbine has been fixed at EL. 772.5 m corresponding to highest tail water level at EL.768.0 m i.e. 4.5 m above maximum tail water level at Powerhouse end. The Contractor shall ensure that runner is not submerged in froth/ water over the entire operating range, including up to 110% load on all machines simultaneously, and with maximum tail water level of 768.0 m

1.4.2 Rated Speed

The speed of the units shall be 375 rpm in anti-clockwise direction when viewed from top.

1.4.3 Pressure Rise and Speed Rise

The maximum pressure rise at turbine inlet, considering the effect of water hammer under worst conditions of load acceptance/rejection and governor closing/opening times shall be indicated by the Contractor. However, the pressure rise shall not be more than 15% of the design head 761.5 m and speed rise shall not be more than 20% of the synchronous speed under any worst condition.

1.4.4 Runaway Speed

The maximum runaway speed shall be stated and guaranteed by the Contractor which shall not be more than 180% of the rated speed. The generating unit shall be designed to withstand the forces and stresses occurring at the runaway speed condition for a period of at least thirty (30) minutes without any damage (without cooling water flow) and safely withstand any transient over speeds. The manufacturer shall furnish the detailed calculations at the time of bid in support of his claim regarding withstand capability of turbine-generator unit at the runaway speed.

1.5 Performance Criteria & Guarantees

The generating units along with all auxiliaries and accessories shall be capable of performing intended duties under specified conditions and data sheets. The Contractor shall guarantee the reliability and performance of the individual equipment as well as of the complete system.

Field tests shall form the final basis to establish fulfilment of guarantee of the turbine and for purposes of liquidated damages and rejection of the plant.

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1.5.1 Guaranteed Output

The Contractor shall guarantee the following turbine outputs at shaft coupling at rated speed of 375 rpm:

i) Rated output not less than 152.3 MW (150MW @ generator terminals) at a design head of 761.5 m with 85% nozzle opening,

ii) 95% nozzle opening output of not less than 167.51MW (165MW @ generator terminals) at a design head of 761.5 m.

1.5.2 Guaranteed Efficiency

The guaranteed weighted average efficiency at the design head shall not be less than 92 percent and shall be calculated as follows:

$\eta_{aw} = 0.18 \times \eta_{110} + 0.31 \times \eta_{100} + 0.26 \times \eta_{75} + 0.25 \times \eta_{50}$ where,

η_{aw} = Weighted average efficiency

η_{110} = Efficiency at 110 percent of rated output when operating at Design head of 761.5 m

η_{100} = Efficiency at 100 percent of rated output when operating at Design head of 761.5 m

η_{75} = Efficiency at 75 percent of rated output when operating at Design head of 761.5 m

η_{50} = Efficiency at 50 percent of rated output when operating at Design head of 761.5 m

Liquidated damages shall be imposed as per Clause 1.5.6, "Liquidated damages for shortfall in output and efficiency" in case of shortfall in weighted average efficiency vis-à-vis the corresponding guaranteed value.

The liquidated damages on account of shortfall in weighted average efficiency shall be computed separately for each unit and the total amount of liquidated damages shall be the sum of all the units.

However, tolerance in computation of efficiency shall be in accordance with the IEC 60041-1991 for field acceptance test for hydraulic turbines.

1.5.3 Prediction of Guarantees from Model Test

The field test as per IEC-41 shall form the basis for determining and fulfillment of the guarantees. However, turbine model test shall be conducted by the supplier prior to taking up the manufacturing works, so as to predict the performance and demonstrate capability of design offered to meet all guarantees and provide trouble free and smooth operation of turbine.

Based on model test modifications in the design, if necessary, shall be made, so that the guaranteed performance of the prototype can be ensured during field tests on prototype. Manufacturer shall proceed with, only after satisfactory results are obtained.

In case of inability to obtain such satisfactory results, the Employer reserves the right to cancel the contract.

1.5.4 Cavitation Pitting Guarantee

The Contractor shall guarantee that pitting due to cavitation during a period of twenty four (24) months or 8000 operating hours, whichever is earlier, from the date the unit is placed in to commercial operation, will not impair the strength of the runner or be measurably detrimental to the efficiency or power output of the turbine.

During first 8000 hours of operation, the cavitation, if any should not be such as to impair the strength of runner and metal loss shall not exceed the provision under IEC-60609-Part-2.

Excessive pitting shall be defined as the removal or loss of metal from the runner due to cavitation pitting exceeds the below limit:

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i) Smax (cm) > 0.2 B0.5

ii) A (cm2) > 300 B1.7

iii) V (cm3) > 60 B2

Where:

B is Inner bucket width in (m)

Smax is maximum depth in cm

A is the total Area of the whole runner damaged by cavitation pitting in cm2

V is the total Volume of material of the whole runner removed by cavitation pitting in cm3

For cavitation evaluation, unit operation from 110% - 6% load shall be considered as Continuous normal operating range.

If the 24 months guarantee period expires prior to the completion of 8000 hrs. of actual operation, the contractor shall guarantee that the weight loss shall not exceed the value proportional for the number of hours actually operated.

If any of the runner or any individual turbine component fails to meet the above guarantee, the Contractor shall, at his own expense, repair the pitted area by welding and also repair in a satisfactory manner all other areas, at the same location, of other water passages or identical turbine components where similar damage due to the same cause may have occurred although to a lesser extent.

The Contractor shall also make the necessary alterations to remove the cause or causes of the pitting or, if necessary, shall replace the runner. Subsequent to repair, the repaired runner and turbine components will be subject to the above pitting guarantee for another period of 8,000 operating hours of power production. The replaced runner shall be subjected to same guarantee clause as the original runner. Cavitation inspection will be carried out after first year or after 4000 hours of operation at which time the Contractor can assess the amount of damage and effect minor corrections.

1.5.5 Cracking Guarantee

The Contractor shall guarantee that there shall be no crack development at the critical location (viz. root area) of the Pelton runner within the Defect Notification Period. In case any cracks are observed in the critical locations during the defect notification period, the same shall be treated as failure which shall require its complete replacement within a mutually agreed time frame.

1.5.6 Liquidated Damages for Shortfall in Output and Efficiency

The Contractor shall guarantee the weighted average efficiency of turbine which shall be verified through model test and field efficiency test. Liquated damages shall be imposed or reject the runner turbine if the contractor fails to achieve guaranteed values during model acceptance or field acceptance test. During the model acceptance test, the contractor has to modify the design, if the efficiency of the model is found less than the guaranteed valve offered by the Bidder in their Bid. Modifications in design, if necessary, shall be made within a reasonable time not exceeding three (3) months so that the guaranteed performance can be obtained and the manufacturing shall commence only after satisfactory results are obtained in the model test. In the event of extra time taken by the manufacturer for rectification of design deficiencies, the delivery schedule as agreed earlier shall be adhered by the contractor. In case of failure to obtain satisfactory results to ensure guaranteed performance, the purchaser reserves the right to cancel the contract or to accept the same subject to levy of liquated damages as specified below.

For any shortfall in the tested values of rated output and the weighted average efficiency of turbine vis-à-vis the corresponding guaranteed values respectively, shall be computed as follows:

(A) Output

For each one hundredth of one (1) percent (0.01%) shortfall in tested value of rated output of not less than 152.3 MW at a design head of 761.5m vis-à-vis corresponding guaranteed value	Equivalent to **INR/NU 13.09 Million**

(B) Weighted average efficiency

For each one hundredth of one (1) percent (0.01%) shortfall in tested value of weighted average efficiency vis-à-vis corresponding guaranteed value	Equivalent to **INR/NU 13.09 Million**

For fractional values of shortfalls in percentage, the liquidated damages amount will be computed on pro-rata basis.

The liquidated damages on account of shortfall of output and weighted average efficiency shall be computed separately. The total amount of liquidated damages shall be the sum of these two multiplied by number of turbines.

No tolerance limits shall be permissible over the calculated value of rated output. However, tolerance in computation in efficiency shall be in accordance with the IEC 60041-1991 for field acceptance tests for hydraulic turbines.

1.5.7 Rejection Limit for Short in Output and Efficiency

The Employer reserves the right to reject the turbine if the tested values of either weighted average efficiency or the rated output of 152.3 MW, at design head of 761.5 m falls short by one (1) percent or more of the corresponding guaranteed values during field acceptance tests.

1.5.8 Tender Evaluation on Account of Efficiency Differences

For the purpose of comparison of bid, the quoted prices shall be enhanced by capitalization for the shortfall in efficiency and output at the rate of Nu/Rs.13,090,000.00 (Thirteen million Ninety thousand) per one hundredth of 1% (0.01%) difference to the highest value quoted by any one of the bidders. Loading for all the four turbines shall be considered for equalization. No change in the values of efficiency/output Quoted in guaranteed & technical particulars shall be permitted after opening of bids & evaluation will be carried out on the basis of information furnished by the bidder in the bid.

1.5.9 Smooth Operation and Noise Limit

Turbine design shall be such as would ensure smooth and quite operation with low vibrations, pressure pulsations, power fluctuations and noise. The vibration amplitude at the shaft shall not exceed the values specified in ISO-7919(part 1) and ISO-3945.

Contractors shall guarantee that the detrimental pulsations (both for Pressure and Power) do not occur at any load and during transients i.e. at steady condition form 6% (Six) load to rated load of the generator.

The maximum noise level, including transient conditions (Start, load rejection or surge), at a place 1 m distance from turbine shaft shall not exceed 85dB, and the same shall be guaranteed and proved at site by actual measurement. Design provision made for achieving these guarantees shall be elaborated during design stage.

1.5.10 Speed Rise and Pressure Rise

The data on speed rise, speed drop shall be given as asked for in the schedule of guaranteed particulars. The regulation shall be obtained from the unit operation alone independent of the effects of the rest of the system.

The flywheel effect of the generating unit and closing time of the deflector and nozzle shall be so adjustable that the speed rise of the unit shall not exceed twenty percent (20%) of the rated speed at any operation condition.

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The spear shall be moved by its servomotor under governor control. The pressure rise shall not exceed 15% (fifteen percent) of the maximum static head under any condition of operation at the center line of distributor/MIV. The rate of closing and opening shall be so controlled by timing device that pressure variations at the center line of distributor/MIV including the penstock are kept within limits specified above. The spear shall act in conjunction with the deflector operated by a separate servomotor so that when load is suddenly rejected, the pressure rise is checked by cutting-off supply of water to the runner quickly.

1.5.11 Operating Temperature Limits

The guide bearing metal temperature under permissible operating range of the turbine shall not exceed 70^0C (Seventy deg. Celsius) with maximum cooling water inlet temperature of 30^0C.

1.5.12 Cooling Water Failure Duration Withstand Capacity

The turbine guide bearing shall be designed and guaranteed to withstand operation without any damage or deterioration for a period of at least thirty (30) minutes with rated speed and maximum output (excluding coasting down period) without cooling water supply.

1.5.13 Model Tests

1.5.13.1 General

Turbine model test shall be performed in an approved test laboratory in presence of a team of the Employer, to demonstrate that the efficiency and other guarantees, as well as the requirements of the specifications for the performance of the turbine, will be met.

The model test shall be conducted within four months following the award of the contract and four (4) hard copies of the "Model Test Report" and four (4) soft copy shall be submitted for perusal of the Employer.

The tests shall be as per latest IEC test code publication No. 60193 "International code for Model Acceptance Test of Hydraulic Turbines". The step-up of the model efficiency to the prototype efficiency shall be in accordance with IEC Publication 60995.

Model test results shall be subject to the approval of the Employer and the Contractor shall commence manufacture of the prototype after approval for the same has been accorded.

Model shall be fully homogenous as per IEC 60193, in addition to specific requirements below.

The model high pressure reference section shall be located at the penstock connection to the upstream make-up pipe of the MIV. Gaps and details inside the MIV supply shall not be represented.

The model tailrace shall be represented up to four (4) Pelton diameters downstream of the unit centerline.

Buckets shall be numerically machined inside and outside and dimensionally controlled immediately after machining and polishing.

The spiral distributor shall be split in the symmetry plane in order to facilitate the dimensional control and represent weld joints realistically.

The turbine housing shall be equipped with Plexiglas windows.

1.5.13.2 Place of Model Test

The laboratories proposed shall be accredited by reputed agencies. The list of laboratories shall be approved by the employer before proceeding for the model test. Employer reserves the right to get the model tested in any of the renowned approved test laboratory or Contractor's facilities/ recommended agencies by the Contractor.

In case model tests are conducted at the Contractor's facilities, the Contractor shall guarantee the repeatability of the results within the allowance provided in IEC. Nevertheless, the

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Employer reserves the right to get the model test repeated in presence of both the parties in an internationally recognized independent laboratory at his own cost.

The Contractor shall supply his model test data, method of testing from previous tests and turbine model, for each component of turbine, to the laboratory selected for conducting the tests, if it is different than the Contractor's facilities.

1.5.13.3 Tests to be conducted on Model

The model tests shall be conducted in range of unit speeds corresponding to 65 % to 125 % of design head and nozzle opening corresponding to no-load to 100% opening. The nozzle positions shall be superimposed on the efficiency contours. The model 'hill' diagram shall show unit flow / unit power versus unit speed or head with lines of constant efficiency, power, nozzle position and cavitation limits. The prototype 'hill' diagram shall show prototype power output versus head with lines of constant efficiency, flow, nozzle position and cavitation limits. Prototype curves of efficiency, flow and nozzle position versus power output shall be made for design heads corresponding to 65% to 125% of design head. Axial thrust at various operating points at each nozzle opening shall be measured and plotted on model and prototype hill chart.

The cavitation limits, runaway speed characteristics, hydraulic thrust, shall be determined by the laboratory tests on model.

The efficiency characteristics of the homologous turbine shall also be determined and the complete 'hill' diagrams of both model and prototype shall be incorporated in the report.

The step-up of the model efficiency to the prototype efficiency shall be in accordance with IEC 60995.

Runaway speed tests shall be made to determine the maximum runaway speeds under conditions corresponding to prototype design heads with range of 65% to 125% of design heads with the nozzle selection and nozzle opening that produces the highest runaway speed.

The model test shall include but not be limited to the following tests:

i) Efficiency Tests,
ii) Determination of peak efficiency of the model and estimation of peak efficiency of the prototype,
iii) Measurement of flow, hydraulic thrust and runaway speed tests at various openings and unit speeds corresponding to 65% to 125% of design head,
iv) Complete Hill chart,
v) Verification of dimensions of various sections of distributor, nozzles, Runner bucket etc.
vi) Runaway characteristics at various nozzle selection and openings.

The model test shall simulate all possible operating conditions of the prototype for the entire range of operation at unit speeds from 65% to 125% design head.

The equations specified in relevant clauses of the IEC Model Test Codes shall be used for discharge and speed. Detailed calculations shall be submitted by the Contractor.

1.5.13.4 Model Test Report

After completion of the model tests, the Contractor shall submit to the Employer four (4) hard copies and four (4) soft copies of the model test reports for approval within 14 days. The test report shall include, but may not necessarily be limited to the following:

i) A description of the close loop test facility, test equipment's and test procedures used for model testing,
ii) Sample calculations for all calculated parameters including efficiency, cavitation and run-away speed for the model and step-up for the prototype,

iii) Comparison of test results with the guarantee requirements of specification/contract and technical conclusions,

iv) Model test curves for:

a) Unit power, unit discharge, efficiency versus speed for various nozzle openings,

b) Relation of power output, efficiency to various nozzle openings and speeds corresponding to the head range to be encountered in service,

c) Relation of runaway speed to nozzle opening at the 65% to 125% of the design head.

d) Hill diagram as specified above.

v) Prototype turbine curves showing:

a) Relation of efficiency, turbine output and discharge,

b) Relation of turbine discharge with nozzle opening for the head range of 65% to 125% of the design head,

c) Relation of runaway speed to nozzle opening for the design heads of 65% to 125% of the design head.

vi) Detailed dimensional drawing of the model turbine, including the runner, nozzle, and spiral distributor used for the tests,

vii) A sample calculation for each computation from data to final result,

viii) Sample calculation, step-up of each measurement point and calculation of the prototype weighted average efficiency,

ix) Radial thrust measurement,

x) Flow observations and tail water level influence on Model performance,

xi) Runner loading and stress analysis report,

xii) Record of calibration of all test instruments and equipment:

a) Flow meter calibrations in the flow test range before and after the test,

b) Pressure transducer calibrations for the head range before, during and after the test,

c) Torque transducer calibrations and daily zeros,

d) Calibration certificates for primary calibrations.

xxii) Dimension control on a CMM of 4 buckets selected by Employer, inside and outside, and determination of normal distances to the design surfaces on a CAD system. Deviations shall not exceed 0.15mm,

xxiii) Description of test results, comparison with the guaranteed data and technical conclusion.

1.5.13.5 Model Acceptance

i) Within 30 (thirty) days following the receipt of the model test report, the Employer shall communicate his decision of the model test to the Contractor. The Contractor shall commence the manufacture of the prototype only after the approval of the model has been accorded.

ii) The final report shall be approved within one (1) month from the date of receipt of the report.

iii) Should the model fail to meet the requirement of guarantee and other requirements, the Contractor shall modify the same until it complies with the requirements. All expenses involved for the modification and subsequent model tests shall be borne by the Contractor. The Contractor shall make good and meet the guarantee again within shortest possible time from the date of witnessing the original model tests. No delay, however, will be allowed in the original delivery schedule due to this reason.

1.5.13.6 Field Acceptance Tests

Capacity and efficiency tests shall be conducted to verify that the output guarantees are met.

The efficiency tests shall be conducted on one turbine, chosen by Employer at a later date, by the contractor in the presence of the employer's representatives or nominated experts. The scope of works shall include all preparatory works, helpers, etc.

The power output test shall be carried out on each unit.

The power output and efficiency tests on the turbine shall be made at net effective head as near as practicable to the design head. The efficiency test shall be made by the thermodynamic method. The alternative method can also be suggested by the bidder. The turbine capacity shall be determined from electrical measurements of generator output corrected for generator losses. The generator losses shall be determined from the generator efficiency curves and verified by measurement of air cooler and bearing heat losses.

The turbine efficiency and capacity tests shall be conducted in accordance with the provisions of IEC Publication 60041, International Code for Field Acceptance Tests of Hydraulic Turbines. The test shall be conducted under the direction of a qualified independent expert to be decided by the Employer, unless otherwise mutually agreed upon by the Contractor and the Employer. The costs will be borne by the Contractor.

In addition to the field acceptance test, an Index test for flow measurement by acoustic method shall also be performed after calibration of both the equipment's i.e. Winter Kennedy apparatus and acoustic flow measurement system in accordance with IEC.

i) To determine the performance characteristics as expressed by the relative values of power, discharge and efficiency,

ii) To conduct Index test to check the deterioration in performance of the machine with time.

1.6 Design and Construction

1.6.1 Design Stress Limits

Design stress limits shall be as per clause 4.2.1.2 "Maximum allowable stresses" of General Technical Specification".

1.6.2 Material Selection and Standards

The material specifications and their standards for major components of Turbine shall be as shown below. The material grade and classification wherever specified are obligatory and proposed equivalent national/international standard for the same shall also be considered if their chemical composition, mechanical properties, manufacturing methods are similar/superior and are suitable for proposed use. The Contractor shall establish the equivalence/superiority for acceptance by the Employer.

Sl. No.	Item	Material	Material Standard
1	Runner	Fully forged, Stainless Steel, 13Cr-4Ni,	ASTM A 743 Gr CA 6NM / GX4 Cr Ni 13-4, EN 10283
2	Turbine shaft	Forged steel	ASTM A 668 Cl D / E / F / P355QH1, EN 10222-4
3	Coupling bolts	Alloy steel NiCrMo	ASTM A 434 Class BD / ASTM A 540 Gr. B 23 Cl 3 / 30CrNiMo8 ISO 683-2
4	Turbine housing	Carbon steel	ASTM A 537 Class II or ASTM A 516 Gr.70 / S355J2+N, EN 10025-2

Sl. No.	Item	Material	Material Standard
5	Pit Liner	Carbon steel	ASTM A 537 Class II or ASTM A 516 Gr.70
6	Distributor	Carbon steel	ASTM A 537 Class II or ASTM A 516 Gr.70 / S355J2+N, EN 10025-2
7	Nozzle Body	Carbon steel	ASTM A 537 Class II or ASTM A 516 Gr.70 / S355J2+N, EN 10025-2
8	Needle	Stainless Steel, 13Cr-4Ni, With hard coating	ASTM A 473 S41500/ GX4 Cr Ni 13-4, EN 10283
9	Nozzle Seat Ring	Stainless Steel, 13Cr-4Ni, With hard coating	ASTM A 473 S41500/ GX4 Cr Ni 13-4, EN 10283
10	Deflector	Stainless Steel, 13Cr-4Ni,	ASTM A 473 S41500/ GX4 Cr Ni 13-4, EN 10283
11	Nozzle & deflector servomotor	Carbon steel	ASTM A 537 Class II / S355J2+N, EN 10025-2

1.6.3 Fixed/ Embedded Components

1.6.3.1 Distributor

Distributor shall be designed to withstand the maximum internal pressure without any support from the concrete. This internal design pressure results from the maximum static head at the distributor center-line, including pressure rise due to water hammer.

The distributor pipe shall be approximately spiral form. The spiral distributor shall be built up from carbon steel plate. The design shall be such that hydraulic losses are minimized. It shall be of welded steel plate construction and shall be embedded in concrete.

The distributor pipe shall be designed for fabrication in sections and shall be shop fabricated to the greatest practicable degree, with welded field joints as necessary only to meet handling and shipping limitations. The distributor pipe plates shall be accurately formed and fitted so that edges of adjoining inside surfaces match together. The distributor pipe shall be connected to the shut-off valve by flanged removable extension pipe with a sleeve type coupling between the extension pipe and the distributor to facilitate the removal.

The distributor shall be designed for minimum internal design pressure of 92 bars. Three (3) mm corrosion and abrasion allowance in the thickness of distributor shall be taken.

A hydrostatic pressure test of the distributor assembly shall be conducted before concreting for each unit at a hydrostatic pressure of 1.5 times maximum internal design pressure as per standards. Required quantity / numbers of testing arrangement i.e. test cylinder (s), bulks head(s), pump – Motor set etc. shall be provided by the contractor to meet the schedule.

Distributor shall be concreted in pressurized condition up to a suitable pressure by the Contractor.

Piezometer & other necessary tapings shall be provided for the measurement of various parameters for field test etc. The piezometer board shall be equipped with test fittings for ultrasound tests. All piezometer pipes shall be of minimum schedule 80 and seamless stainless steel. All the piezometer tubes/pipes shall be properly sleeved in a pipe of higher diameter or with channel and angles.

1.6.3.2 Accessories

The following accessories shall be included:

i) Four pressure taps of stainless steel with pipe connections on the inlet section suitably located and arranged in accordance with the recommendations of the international Code

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for the Field Acceptance Tests of Hydraulic Turbines IEC 60041-1991 for pressure measurements and for connection to the distributor pipe pressure gauge (to be mounted close to the distributor inlet) and to pressure transmitter for remote indication on the turbine terminal cubicle,

ii) A distributor drain outlet with heavy removable stainless steel grating connecting drainpipe from the lowest point of the distributor pipe with the tailrace pit shall be provided. The piping shall include a flanged drain valve and an easily removable pipe extension or sleeve-type coupling to facilitate removal of the valve for maintenance and to avoid any bending in the piping,

iii) All necessary stiffener rings, pads or brackets and connections for the application of jacks and tie rods during field erection as well as all spiders or bracing required to prevent distortion to the distributor pipe sections during transportation and erection. These appendices shall be designed to support and position the distributor pipe and extension during all conditions of installation,

iv) The first section of the distributor shall be provided with a water tight access man door of not less than 750 mm diameter for inspection,

v) Suitable air release valve should be provided at appropriate location on the downstream side of MIV to allow air trapped in the penstock to escape when it is filled with water through bypass valve and for supplying/admitting the air when the MIV is suddenly closed. It shall be operated by distributer water pressure (Valve should automatically close when the distributer is fully filled and pressurized and should open while draining). The valve shall also have potential free NO+NC contacts for control and indication purpose. Necessary coordination shall be made with the MIV manufacturer for design and control of this valve,

vi) Suitable bosses with flanges to receive by pass valve piping of spherical valve,

vii) Test heads made of steel shall be provided for closing the distributor pipe inlet and the nozzle flanges, during field hydrostatic testing and distributor embedment. The test heads shall be used for all units and shall be shipped with the first unit. The test heads shall be removed after completion of the hydrostatic test and embedment of the distributor pipe,

viii) The test heads shall be provided with pipe connections for filling the distributor pipe, pressure gauge, and thermometer & pressure relief device, if necessary and shall have lifting attachments to facilitate handling by crane.

1.6.3.3 Turbine Housing

The turbine housing liner shall be of welded carbon steel. The liner thickness shall not be less than 20 mm suitably stiffened with ribs and it shall be sufficient to ensure adequate rigidity during concreting. The liner shall cover completely the inside of the turbine housing including the housing roof. The housing liner shall be fabricated in the least number of sections practicable for handling and shipment. The liners hall is so designed to prevent the water leaving the buckets from being deflected back against the runner. The liner shall not be designed to support any load due to the generator/turbine. Necessary concrete anchoring shall be provided. Adequately sized air admittance piping enabling the turbine to draw air from outside shall be provided. An opening in the turbine housing liner shall be provided matching with the size of runner removal gallery.

Suitable number of holes not less than 150 mm in diameter shall be provided to facilitate the placing of concrete with provision of sealing the holes after concrete is placed. Adequate number of suitably spaced 20 mm diameter tapped grout holes covering each grid formed by ribs shall be provided to facilitate final low pressure grouting of the liner after shrinkage of the embedding concrete has taken place. Suitable plugs shall be installed for the grout holes and ground flush after grouting is completed.

Necessary holes for tapping/routing the nozzle oil/water leakage pipelines shall be provisioned in the turbine housing.

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1.6.3.4 Pit Liner

A pit liner, made of carbon steel plates, shall be located under the housing construction. The liner thickness shall not be less than 20 mm suitably stiffened with ribs and it shall be sufficient to ensure adequate rigidity during concreting. The connection between turbine housing and pit liner shall be of a welded type effectuated on site. The pit liner shall be fitted with anchorage bolts. Energy absorbing baffles or other approved means shall be provided to absorb the energy of the deflected jets, unless such energy absorbing devices are furnished on the nozzles. Suitable energy absorbing baffles or other means shall be provided to absorb the energy of water from drainage system.

Suitable number of holes not less than 150 mm in diameter shall be provided to facilitate the placing of concrete with provision of sealing the holes after concrete is placed. Adequate number of suitably spaced 20 mm diameter tapped grout holes covering each grid formed by ribs shall be provided to facilitate final low pressure grouting of the liner after shrinkage of the embedding concrete has taken place. Suitable plugs shall be installed for the grout holes and ground flush after grouting is completed.

1.6.4 Stationary/ Removable Components

1.6.4.1 Injector System

Nozzles shall be of the straight-flow type with internal hydraulic servomotors. The nozzle assembly shall be removable and the design shall incorporate lugs or other means for raising and lowering the assemblies. Adequate adjusting rings shall be provided for each nozzle to ensure correct alignment of the nozzles.

The nozzles shall be fabricated from carbon steel plate. Critical parts at final discharge of the nozzle head shall be replaceable and of stainless steel. The welds shall be fully penetrated and stress-relieved before final machining. The nozzles shall be of heavy rugged construction such as to support the load of deflector system and it shall be sectionalized as necessary for easy accessibility of needle servomotor.

The needles shall be regulated by hydraulically operated servomotors internally installed in the nozzle torpedo.

The nozzles shall be furnished with appropriate flange connections as required for easy dismantling and shall be designed to minimize hydraulic losses to the maximum extent possible.

The nozzles shall have a self-closing tendency due to penstock pressure and spring action in the event of failure of the governor oil pressure, or breakage of any connecting mechanism. Such automatic closing shall be at a controlled rate, which will not result in a pressure rise greater than 15% (fifteen percent) of maximum static head. Needle servomotors shall be double acting hydraulic jacks with spring assistance.

The needle tips and seat ring will be made of stellite massive and HVOF tungsten carbide coating.

Needle tips and seat rings shall be removable and interchangeable. All needle tips and seat rings attachments, including bolts, nuts and other fasteners, which are exposed to air and water, shall be of corrosion resistant materials.

The critical parts at final discharge of the nozzle head viz. needle tips/seat rings/nozzle hat/head and deflector shall be replaceable/interchangeable without dismounting the nozzle injector assembly from the distributor.

The injector system shall be designed in such a way that the interval of major overhauling of Nozzle injector assembly viz. dismantling of injector assembly and replacement of seals shall not be less than five (5) years from the commercial date of operation.

The nozzles pipes shall be pressure tested after complete assembly applying 1.5 times the design pressure.

A replaceable shield for nozzles for protecting nozzles from adjacent nozzle`s deflected jet or runner`s exit water may be provided with nozzles.

1.6.4.2 Deflector System

Governor controlled push-out jet deflector shall be provided on each nozzle which shall be actuated by individual servomotor. The deflectors shall be operated simultaneously. The nozzle body will be adequately reinforced to support the jet deflector. The deflector and the supports will be designed to prevent any harmful vibrations during operation, including complete load rejection and to ensure that no deflector can contact the runner in the event of operating mechanism breakdown.

The deflectors will be of rigid design integrally cast or forged. The surfaces subjected to high-speed flow will be adequately lined by a hard stainless steel lining to resist erosion and cavitation. Each deflector will turn on a shaft of stainless steel, supported in two self-lubricating guides and thrust bearings. All components of the deflector to be inside the casing and subjected to air and water shall be of corrosion resistant materials. Each deflector shall be provided with an external position indicator.

The deflector shall be capable of deflecting the jet completely under the most severe operating conditions within a time period of two (2) seconds or less.

The turbines shall be equipped with twin regulations (nozzle-and deflector regulation).

The deflector shall only enter the jet in the event of a quick load decrease which cannot be handled by the needles. The deflector shall deflect the jet until the needle approaches the required position for maintaining the normal speed.

1.6.4.3 Brake Jet Assembly

Each turbine shall be fitted with one or two nozzles intended to emit a brake jet, to be automatically operated during fast shutdown of the generating set. The brake nozzles(s) will be fed from a pipe connected to a flange provided at MIV Body. The hydraulic brake shall be of the water-jet type and shall conform to the following requirements stated hereunder.

The hydraulic brake shall be applied on signal from electric control devices, after the deflectors reach the closed position and the generating unit circuit breaker is in the open position. The braking jet shall not be used during normal scheduled shutdowns. **The jets of the brake nozzles shall be directed against an insensitive area on the backside of the buckets (not in the center part) in a way as to prevent excitation of cloverleaf vibrations of the bucket ring. If required twin-brake nozzles are to be furnished.**

The hydraulic brake shall be capable of reducing the speed of the generating unit from one hundred twenty (120) % of rated speed to thirty (30) % of rated speed in approximately eight minutes. The generator pneumatic bake will be applied continuously below this speed.

The hydraulic brake system shall consist of the following principal parts for each brake jet:

i) Pressure water supply outlet from the by-pass valve of the spherical valve,
ii) One set of high-pressure piping and necessary fittings,
iii) One needle nozzle or needle valve and nozzle, suitably located to apply the braking jet to the reverse side of the runner. The needle tip shall be of stainless steel and renewable,
iv) One governor oil pressure operated servomotor for needle or valve operation.
v) One 220-volt DC solenoid operated control valve,
vi) Two non-contact type switches for remote indication of position,
vii) Brake jet shall be connected to the by-pass valve of the spherical valve. For repair of the brake jet, closing the by-pass valve/MIV maintenance seal shall isolate the same.

1.6.4.4 Servomotor and Control of Turbine Discharge

The control of the discharge, necessary to accompany changes in load, shall be accomplished by means of the needles, which shall close or open automatically under governor control to meet the load demands.

The type of control system shall be through governor actuated needle and deflector servomotors. Each needle and deflector shall be controlled by its own servomotor, thereby maintaining its opening at the selected value, or modifying it according to the orders of the electronic governor head into a speed proportional to the oil flow given by the distributing valve. Each needle control valve shall be provided with a manual lock, which can be set to limit needle stroke as a load limit or maintain its respective needle in the closed position regardless of deflector position.

The operation of the needles and jet deflectors shall be such as to accommodate the changes in water supply, with a minimum of oscillation in the output of the unit, and with a minimum of pressure rise in the penstock. For small or slow changes in load, the deflectors shall not enter the jets, but for rapid load rejection, the deflectors shall deflect the jets clear of the runner. Under normal speed control the needles will do the governing and water will not be wasted.

Means shall be provided which will permit selection for the number of nozzles in operation. For part load operation, for better efficiency and when one or more nozzles are out of service the remaining nozzles shall still be properly governed. Selection of number of nozzle shall preferably be automatic self-selection type on part load.

The control valve in the governor for controlling deflectors shall be actuated by a signal from the governor.

The deflector servomotor shall be of the oil pressure actuated, double acting type with spring bias for closing of sufficient capacity to supply the maximum forces required to operate the deflectors through full stroke, with minimum governor operating pressure.

The cylinders shall be accurately bored and provided with suitable sealing around the operating rods. The operating seals shall be of the automatic pressure actuated type. There shall be positive margin in the cylinder with respect to full stoke length or any other alternate arrangement either in piston or cylinder for avoiding seizing of Servomotor when fully opened for longer period.

Provision shall be made so that each needle can be positioned independently by the governor. All working joints and pin connections throughout the operating mechanism shall be properly bushed and provided with self-lubrication. Means shall be provided to permit adjusting the opening and closing times of the needle stroke to any value within the following limits:

i) Full opening stroke 10 to 30 seconds.

ii) Full closing stroke 10 to 30 seconds.

(Above given details are Tentative, Bidder shall confirm as per Transient analysis or as per Design)

The rates of travel for deflector and needle servomotors shall be independently adjustable for the closing and opening directions.

Water pressure shall be sufficient to hold the needles in closed position when machine is under shutdown. A calibrated scale shall be provided to indicate deflector/ needle servomotor stroke length.

Each servomotor assembly shall consist of a cast or welded steel cylinder, cast steel piston, piston rod, glands and necessary compensating mechanism. The needle servomotors shall be of the oil pressure double acting type with spring bias for closing. Suitable transducer for needle position transmission shall be provided on restoring shaft of each needle. The output (4-20mA) shall be suitable for static data acquisition and control system. The servomotors will be

equipped with a mechanical feedback position mechanism, for connection with the governor restoring mechanism or transducers, above the turbine casing.

1.6.5 Rotating Parts, Guide Bearings and Seals

1.6.5.1 Runner

i) The runner shall be made of 13Cr-4Ni stainless steel and it shall be fully forged.

ii) The forged disc may be sourced from internationally reputed forging firms. The bidder shall submit to the purchaser along with the bid, a list of vendors that bidder proposes to procure the forged disc. Bidder shall also furnish certificates from the vendors for past supply of forged disc of at least equivalent dimension and tonnage of the proposed runner.

iii) The runner shall be connected to the turbine shaft in accordance with ANSI/IEEE Std. 810 "IEEE Standard Hydraulic turbine and generator integrally forged shaft coupling and shaft run out tolerances" or applicable standard. The coupling shall be proposed by manufacturer as per their manufacturing standard meeting all guaranteed parameters and proving sufficiency by calculation. The coupling bolts shall be designed for tightening using hydraulic tensioner/ tightening device as applicable. However, no bush will be employed along with the coupling bolts.

The runner forging shall be visually inspected immediately after forging and cleaning, and it shall be subjected to NDT inspection methods. The particular zones which shall be subject to radiographic inspection and the bucket lips and junction of the bucket rib with the rim. After these tests, minor cracks and other minor defects, if any, shall be chipped and ground to sound metal. The forging then shall be preheated, welded, and given a post-weld heat treatment. A careful record of all repairs done shall be kept on drawings made expressly for such purposes and shall be made available to Employer. Major defects in the forging that will affect its performance will be sufficient cause for rejection.

After the runner has been completely machined and finished smooth, it shall be subjected to a second complete Magnetic Particle Inspection (MPI). At this point of time, the Employer shall be duly notified of all repairs, which has been made. All approved welding repairs including heat treatment, which are required to be made subsequent to the final machining, shall be performed with full care and high skills. Complete records shall be kept and furnished to the Employer of all such repairs and the runner shall be permanently stamped with the identification numbers assigned to the rough forging.

The contour of the runner buckets shall be accurate and shall be machine finished so that the bucket profile precisely conforms to the model design within the tolerance set out in IEC Publication 60193. However, in view of high anticipated silt concentration runner bucket thickness at outlet edges/splitter shall be approx. 15-20% more than the optimum design. The buckets shall be evenly and symmetrically spaced. The bucket in contact with water shall be ground to a smooth finish and even surface, without any humps or hollows. The final surface finish of the water passages shall be in accordance with latest International standard/practice. The back of the bucket where contact is made with the jet shall also be ground smooth. The junction of the ribs with the rim shall be polished for inspection. Other portions of the runner not machined, but with a rough forged surface, shall be suitably ground down to present an even appearance. Before shipment, the Contractor shall measure the hydraulic surfaces with templates and submit proof that the finished runner contours and shape agree with the tested model and the design requirements.

The runner disc shall be machined and bored to center on male projection at the end of main shaft and to fit tightly to shaft coupling flange, thus ensuring proper centering and alignment of the runner. The bolts holes shall be bored to a jig to match the holes bored

in the lower flange of the shaft thus ensuring interchangeability. Runner and other corresponding parts, including spare runner and parts, shall be interchangeable.

iv) ***The splitter thickness shall not be less 2mm and the splitter tip shall be of conical shape.***

v) The runner shall be suitably designed and constructed to withstand safely any stresses and fatigues developed due to hydraulic unbalance, if any, under all operating conditions, including maximum output, maximum acceleration during start up and under worst conditions of part jet operations as well as stresses developed at runaway speed. Special attention shall be paid to reduce stress concentration of the fillet of the bucket outlet edge/splitter.

Any change in the design of the Pelton runner shall be intimated to the purchaser for acceptance prior to start of manufacturing of the runner.

vi) **Repair during Manufacturing:** The supplier shall ensure that the supplied Pelton runner is free from any cracks and internal flaws. If any defects (within IEC standards) are observed during the manufacturing process, the same along with the methodology to be adopted for the repair of the defect shall be intimated to the purchaser for acceptance of the defect and its repair process. The methodology of inspecting the repaired defect during operation stage shall also be provided to the purchaser for information. However, the acceptance of the defect and its repair process during the manufacturing stage shall not absolve the supplier of any of the guarantees/ warrantees provided under the contract.

vii) The runner shall be designed to support its own mass and the mass of the turbine shaft (when disconnected from the generator), with the runner resting on the turbine housing.

viii) The runner shall be statically balanced in the manufacturing works before dispatch in accordance to ISO-1940/IG6.3 (or the latest edition). All inspection-templates shall be supplied for use in normal O&M schedules of the power plant.

ix) The contractor shall submit proposed stress reliving heat treatment cycle for the runner along with the time-temperature graph, if any heat treatment is proposed to be carried out on the offered runner.

x) A Navier Stokes simulation shall determine realistic pressure fields on the surfaces of the runner bucket.

The contractor shall carry out Finite element Analysis and Fatigue Analysis during detail engineering for approval of the employer. A finite element analysis with normal mesh, using quadratic interpolations, shall be used to evaluate corresponding stress concentrations.

Given these proven hydraulic numerical simulations and fully converged finite element analyses, Contractor shall demonstrate that the Von Mises stress amplitude in the runner is always less than 40 Mpa.

xi) The runner shall be guaranteed against excessive cavitation pitting. Sufficient clearance shall be available for jacking generator-turbine shaft assembly to enable inspection and adjustment of thrust bearing.

xii) High degree of quality control in manufacture, absolute conformity with the model in dimensional homology and perfect balancing shall be ensured. Bolts and nuts for attaching to the turbine shall be provided. Locking devices for coupling nuts shall also be furnished.

xiii) The buckets shall be adequately ribbed for strength and with inlet edges of the cutouts smoothly rounded. The conformity of the bucket shape to the model shall be verified by use of templates or other shop control devices.

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xiv) **Initial Operation / Runner Inspection**

a) During the initial operation of the turbine for sufficient duration, contractor and employer shall jointly check for any cracks on runner buckets and bucket roots (as per schedule agreed between Employer and Contractor). Contractor shall take suitable steps to attend the same which shall include welding, grinding and polishing and other measures as required in presence of Employer's representative. Usual facilities shall be provided by Contractor, including consumables and T& P for this purpose.

b) Any special Tools and Plant, consumable required shall be included under optional spares and T & P. Contractor shall be fully responsible for such field repairs. If propagation of cracks or reappearance of cracks continue even after agreed schedule period of inspection (not exceeding six months), Contractor shall take necessary action for repair/replacement of runner, as required, under warranty clauses.

xv) **In-service Inspection Schedule**

The contractor shall submit all details required for in-service inspection and shall not limit to include the following;

a) In-service inspection frequency,

b) Procedure for elimination of defects without welding,

c) Minor weld repair procedure (Acceptable limit should be mentioned for Project Site repair and Factory repair),

d) Major weld repair procedure (Acceptable limit should be mentioned for Project Site repair and Factory repair),

e) Stress relieving cycle and procedure,

f) Types of electrodes to be used.

1.6.5.2 Turbine Shaft

i) The turbine shaft shall be made of forged carbon steel, ASTM Designation: A668, Class E.

ii) The turbine shaft shall be one-piece construction and shall have an integrally forged, flanged male coupling on the upper end for connection with a female half coupling on the lower end of the generator shaft. The lower end of the shaft shall have a forged flanged coupling for connection with the runner. This flange shall be bored to jig to ensure field fit of a replacement runner. This flange shall be bored to jig to ensure field fit of a replacement runner without machining. The connection at both the ends shall be made with the help of friction clutch system.

iii) The lower shaft flange shall be equipped with suitable backing-out type jacking bolts to aid in removal of the runner. It shall also be provided with tapped holes for attachment of the runner-elevating device. A blind flange with gasket for closing the inspection hole shall be provided.

iv) A collar shall be provided with the shaft to support the shaft and runner on the turbine guide bearing, during removal of the generator rotor. The support shall permit the turbine half coupling to clear the generator shaft coupling. An indelible line shall be scribed on the shaft at a point above the bearing housing. A pointer shall be provided on the bearing cover opposite this line to indicate any lowering of the shaft, and to permit realignment of the shaft after thrust bearing dismantling.

v) The shaft shall be designed for eccentric loading caused by unbalanced operation, due to any combination of nozzles, in addition to torsional loading.

vi) Shaft run out tolerances shall conform to the requirements of NEMA publication MG 5.1- "Vertical Hydraulic Turbine-Generator Shaft Run out Tolerances- Shop Check".

vii) The shaft shall be subject to ultrasonic and other inspections in accordance with relevant provisions of ASTM.

viii) Suitable oil baffles and water deflectors shall be provided between the main guide bearing and runner.

Surface Finish and Inspection Hole

i) The shaft shall be hollow having a diameter of at least 150 mm throughout its entire length and shall have a general outside surface finish of approximately 3.2 micrometers Ra.

ii) The shaft shall be accurately machined and shall be polished where it passes through the guide bearing.

iii) Two bands shall be machined and marked on the shaft for use for verticality and alignment purposes. Additionally, one band immediately above the guide bearing housing location, of at least 100mm width line, shall be machined on the shaft for non-contact type vibration pick up. The band shall be concentric with the shaft with high surface finish of 0.8µ Ra.

iv) The Contractor shall submit a proposed shop inspection dial indicator chart to Employer for approval, and shall perform the approved shop inspection, witnessed by Employer's representative.

v) The high and low points of the coupling face, with bolts to the generator shaft, shall be clearly stamped on the outer cylindrical surface of the turbine coupling half.

Critical Speed

i) The turbine shaft diameter shall be coordinated with the generator shaft diameter. The critical speed of the combined turbine and generator and generator rotating parts shall be calculated by the Contractor and first critical speed shall be at least 25% above the maximum runaway speed.

ii) The Contractor shall calculate the shaft critical speed for the complete assembly of generator and turbine and the calculations shall be submitted, along with the drawing of the shaft to the Employer for approval.

Shaft Coupling

i) The shaft coupling shall be designed as per provision of ANSI/ IEEE 810. The coupling bolts shall be designed for tightening using hydraulic tensioner/ tightening device.

ii) The coupling bolts and nuts for attaching the turbine shaft to the generator shaft, suitable metal guards on both halves of the coupling for covering the coupling bolts and nuts, and all wrenches and special equipment necessary for shop and field assembly of the coupling shall be furnished by the Contractor to perform the shop alignment of the combined turbine-generator shafts.

Shaft and Runner Lifting

i) Provisions shall be made to permit lifting of the rotating parts of the turbine and generator by the generator jacks. Necessary provisions for minimum acceptable limit for the trust bearing inspection and maintenance shall be kept.

Alignment of the Combined Turbine and Generator Shafts.

i) The combined turbine-generator shafts shall be checked for alignment as per the following procedures:

ii) Orientation of the two coupling faces to the position of best alignment, reaming or boring the coupling bolt holes with the two shafts mated together in a position in which the shafts are on a common axis,

iii) Furnishing and installing coupling bolts with nuts and coupling nut guards, and performing the dial indicator run out rotation check, witnessed by the Employer,

iv) The alignment shall conform to the requirements of NEMA Standard publication number MG 5.1 "Vertical Hydraulic Turbine-Generator Shaft Run out Tolerances-Shop Check",

v) Perfect matching at shop is to be made, in a manner that nothing shall be required for alignment at site.

Contractor shall always use rubber or other protection material when slinging/handling the turbine shaft. Supports shall never be provided directly to the guide bearing area of the shaft and supporting shall only be done in the areas near to the flanges. All the machined and polished surfaces shall be mechanically protected during Transportation.

1.6.5.3 Turbine Guide Bearing

The turbine guide bearing for radial support shall be of segmental type with babbit-lining, water cooled self-oil lubricating type. The bearing segments shall be screw set adjustable and removable type for ease and prompt maintenance purpose. It shall be as near as possible to the runner. The bearing arrangement shall be arranged so as to permit vertical movement of the runner and shaft by an amount recommended by the generator manufacturer for adjusting and dismantling the generator thrust bearing, and by an amount sufficient for clearing the male and female portions of the shaft coupling. Arrangement of bearing would be such that it can be inspected without dismantling other turbine parts. The bearing design shall prevent foreign matter or water from entering the bearing running surfaces and the lubrication system or any appreciable loss of oil by leakage, creepage up the shaft or overflow from any part of the oil system.

The bearing shall be designed to withstand the side thrust resulting from any possible combination of operative nozzles and runaway speed. Irrespective of the material used, the bearing shall be stress- relieved before final machining operation.

The bearing support shall be made of cast steel, or welded plate steel of heavy construction, designed to support the bearing rigidly. The bearing support shall be a part of the turbine housing top welded at site to the turbine and design to transmit the load die to maximum side thrust of the runner to the turbine housing. The internal bearing housing made in fabricated plate steel shall be in one piece after welding around the shaft at site. The external bearing housing, also part of the turbine-housing top shall be provided with a cover to prevent dirt or foreign matter from entering the bearing. This cover split in two section and bolted together shall be provided with a suitable inspection opening with covers or transparent windows. The bearing and housing chimney shall be adequately sealed and generously vented to ensure equal pressure on both sides of the internal skirt and prevent oil during deflector operation in particular.

The design of the bearing and oil reservoir shall permit their inspection and adjustment or removal without major dismantling of other parts of the turbine. The bearing design shall be such that no water shall enter the lubricating system, and there shall be no appreciable loss of oil by leakage past the lower oil shedder or by overflow from any part of the oil system under any condition of normal operation, within the range of headwater and tail water elevation from speed-no-load to full load.

The babbit lining on the guide bearing segments shall be high-grade tine base babbit, ASTM designation: B23, alloy No.2 or better and anchored tightly to the shell. The babbit lining shall be accurately bored and shall be suitable for oil circulation. The Journal shall have a surface finish of minimum 0.8 micrometers Ra.

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No damage shall occur to bearings even if temperature reaches 105°C. The expected bearing temperature shall be indicated in the tender. High temperature bearing performance and withstand type test shall be performed in the presence of the employer.

Suitable lifting eye bolts and backing-out studs shall be provided for use in removing and installing the bearing segments.

The bearing shall be capable of the following:

Continuous Operation - Without injury and without exceeding normal bearing metal temperature at any speed from 50% to 110% of rated speed.

Safe operation for at least 30 (thirty) minutes at any speed between rated and runaway speed, and at simultaneously unbalanced jet conditions without injury, and without requiring any overhaul.

Safe operation for at least 15 (Fifteen) minutes with no cooling water flow when starting from normal oil level and temperature without exceeding maximum allowable shoe temperature and without damage to bearing surfaces at rated speed and full load.

Safe operation for at least 5 (Five) minutes at runaway speed without cooling water supply.

Lubrication

Bearing lubrication oil shall be circulated through the bearing by action of the shaft rotation. The lubricating oils system shall be designed so that the temperature of the bearing metal and bearing oil shall not exceed 70°C and 65°C respectively under continuous operation in any operating conditions. The lubricating oils system shall have sufficient capacity to supply the required amount of oil to the turbine guide bearing, and the oil reservoir shall have sufficient capacity to hold all the oil in the entire bearing system, and to provide cool oil to the bearing under conditions of loads. The bearing design shall prevent the leakage of oil down along the shaft and shall provide for returning oil from the bearing to the reservoir. Separate piping for filling and draining the bearing oil from reservoir for oil changing and purifying shall be provided. All circulating devices, strainer and other accessories required for a complete lubrication system shall be provided.

Cooling System

The lubrication system shall be designed so that the temperature of the bearing metal shall not exceed 70°C under continuous operation. If cooling of the lubricating oil is necessary, a corrosion resistant oil-to-water heat exchanger of 90:10 cupro-nickel coils or equivalent though which cooling water can be circulated shall be provided. All connections to the coils shall be made outside of the oil reservoir and arranged so that water from a leaky connection cannot drip into the bearing oil reservoir. The coils shall be arranged to permit removal without dismantling the bearing. The coils shall be free from leakage when tested in the shop under a pressure of 10.0 bars for a period of 1/2 hour. The arrangement shall be subject to Employer's approval at design stage. To regulate the quantity of water flow in the coils a suitable valve shall be provided in the discharge line of the heat exchanger.

The cooling system for the TGB shall be of the external heat exchanger type, without the need for an external pump to circulate the bearing oil.

Bearing Instruments and Devices

i) The contactor shall supply and install the following indicating and protection devices for the turbine guide bearing. All electrical contacts shall be wired to terminal locks in the turbine terminal box:

a) Three (3) or more numbers of Dial Type Thermometer (DTT), liquid expansion type thermometer, two in case of shell and four or more equally spaced in case of more no. of segments/pads for bearing metal and one in bearing oil for bearing

oil temperature indication shall be provided. The devices shall have two sets of separately adjustable contacts for alarm and tripping circuits,

b) Resistance temperature detectors (RTD's) - one in each segment/ pad for bearing metal and two for bearing oil for bearing oil temperature indication and recording at a remote location (The lead extension cables to the terminal box and 3-wire twisted cable shall be suitably shielded. Separate terminals shall be provided in the terminal box for terminating the shields of individual RTD lead extension cables). At least two of the above RTD's shall be configured for rate of rise of temperature,

c) One electromagnetic induction type flow-meter with two electrically separate low-flow alarm contacts and recording at remote location for the bearing cooling water supply, if cooling water is required,

d) One direct visual indicator of the bearing oil level marked in litres along with high & low level and oil level relay along with adjustable high and low level alarm contacts for remote indication. Besides visual indicator, digital oil level meter display shall also be provided,

e) One oil-water contamination detector,

f) Resistance temperature detectors (RTDs) to measure the temperature of the incoming and outgoing water from the turbine guide bearing coolers, if cooling water is required,

g) Temperature indicator for local temperature measurement of the incoming and outgoing water from the turbine guide bearing coolers, if cooling water is required,

h) Pressure gauges at inlet and outlet of the turbine guide bearing cooler with low pressure alarm contacts, if cooling water is required,

ii) Instruments shall be similar to those provided for generator bearings,

iii) Indicating instruments shall be mounted on Unit Control Board of respective unit and length of capillary should be sufficient with 2 meters margin,

iv) Walkway with galvanized/steel chequered floor plates not less than 8 mm thick and stainless steel rails for convenient and safe access to the turbine bearing shall be furnished.

1.6.5.4 Main Shaft Seal

The turbine housing shall be provided with a labyrinth seal or centrifugal water guard, or other equivalent method to effectively seal the point of entrance of the turbine shaft into the runner pit against any water leakage.

1.6.6 Auxiliary Systems and Miscellaneous Components

1.6.6.1 Service Platform/ Central Framework/Doors and Rails

Runner and other turbine components are envisaged for bottom dismantling and to be removed from a hatch provided for each unit .A structural steel platform, support and walkway complete with girders, cross beams and floor gratings of rust free type shall be provided by the contractor in the turbine pit at MIV floor to permit complete removal, access and repair/maintenance of runner, deflectors and needle/nozzles.

The rails on which the motorized runner handling car is to be placed shall be mounted on the platform. The rails shall run from inside of turbine pit all along runner removal gallery up to underneath of hatch. The service platform shall be so designed to withstand the load of heaviest component to be dismantled from bottom along with motorized trolley. The calculations for

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sizing of girder, rails, supporting structure etc. under full loading condition shall be submitted by contractor.

For entry to the platform a suitable hinged type, wheel mounted door of adequate size at the entrance to runner removal gallery may be provided. The door shall be properly sealed (watertight) and no leakage through the door shall be allowed. Additional sealing of flexible rubber type may be provided at the turbine pit such as to stop any water spillage in the runner removal gallery. The rubber sealing shall be hinged from top and it shall be dismountable. A minimum bolting shall be provided for the doors with high quality for faster opening of doors during runner inspection in peak inspection. The door shall be designed to resist all possible water pressure.

1.6.6.2 Walkways, Access Platforms, Hatch Cover, Floor Grating and Stairs

Walkway, platform, staircases, stainless steel handrails etc. shall be provided in the turbine pit to provide convenient and safe access to all operating equipment and points of lubrication. Also galvanized chequered plate/ grating covers shall be provided for runner removal hatch, equipment handling hatches and cables, cable trays, pipes or any other trench/ opening required for completing the floors around and over the works supplied under the contract.

The design of the gratings, stairs and handrails shall be in accordance to clause 4.11.2 of General Technical Specification and shall facilitate easy removal to permit free access to turbine components. Suitable platform along with railing and stairs etc. shall also be provided at turbine- generator coupling level for ease of maintenance. The material for all handrails shall be stainless steel. The platform around the shaft shall be designed to support the weight of turbine guide bearing.

1.6.6.3 Turbine Pit Hoist

Each turbine pit shall be equipped with the necessary lugs and circular monorails having two nos. cross beams and two hoists covering the entire pit from turbine guide bearing housing to facilitate easy replacement of all equipment.

1.6.6.4 Access Door to Turbine Pit

The turbine shall be provided with a metal acoustic access door to be installed in the turbine pit concrete wall. The door shall have suitable handles and inside panic release bars.

1.6.7 Control and Monitoring

The turbine and associated accessories/equipment shall be controlled and monitored at three levels:

i) By respective local control cubicles,

ii) By respective Unit Control Boards,

iii) By computerized control and monitoring (SCADA) system through Unit Control Boards.

The Contractor shall make provision of contacts and/or ports in local control cubicles for interfacing with UCS and SCADA system for control and monitoring.

Local control shall be performed in an independent and standalone manner, and all information (faults, alarms, measurement, status) necessary for such control shall be displayed locally.

If the system consists of redundant subsystems, the priority of operation of such subsystems shall be selectable either from SCADA system or locally.

1.6.7.1 Instrumentation

The Contractor shall include suitable and reputed makes instruments, gauges, switches, contacts for achieving desired requirement of microprocessor based Supervisory Control and

Data Acquisition (SCADA) System and UCS including facility for auto start-stop of unit, control, monitoring and fault diagnosis.

List of instruments to be furnished per unit with their location is given in Table below. However, the list is indicative only and scope/type shall be as per approved drawings/bill of materials during detail engineering**.**

Sl. No.	Description	Type of Instrument	Quantity
1	**Penstock**		
1.1	Turbine Discharge	Ultrasonic or any other suitable type	1
2	**Turbine Water Path**		
2.1	Distributor Pressure	Pressure Gauge	2
2.2	Distributor Pressure	Pressure Transducer	2
3	**Turbine Bearing**		
3.1	Turbine bearing metal temperature	Dial type thermometer with adjustable contacts	2/4 in shell segment/ pad
3.2	Turbine bearing metal temperature	Resistance temperature	Bearing metal temperature
3.3	Turbine bearing oil temperature	Dial type thermometer with adjustable contacts	1
3.4	Turbine bearing oil temperature	Resistance temperature detector	2
3.5	Turbine bearing cooling water temperature	Dial type thermometer with adjustable contacts	1
3.6	Turbine bearing cooling water temperature	Resistance temperature detector	2
3.7	Turbine bearing oil level relay	Indicating gauge with high and low level contacts and remote indication	1 gauge &1 level transducer
3.8	Float type oil level gauge	Indication for high and low level	1
3.9	Turbine bearing oil level	Digital oil level meter	1
3.10	Turbine bearing cooling water flow	Electromagnetic type flow meter with low flow alarm contacts for local and remote	1
3.11	Turbine bearing cooling water pressure at inlet and outlet, if applicable	Indicating pressure gauge at inlet and outlet and pressure transducer at outlet	2 gauges and1 pressure transducer
3.12	Turbine	bearing cooling water temperature at inlet and outlet, if applicable	Indicating thermometer and resistance temperature detector
3.13	Water in oil detector	Moisture detector with alarm and indication	1
3.14	Vibration detector	Displacement type	1
4	**Needle Position**		
4.1	Needle position indicator	LVDT mounted on servomotor with contacts	6

Sl. No.	Description	Type of Instrument	Quantity
4.2	Servomotor mechanical locked position detector	Position indicator mounted on each servomotor with contacts	1
5	**Dam Water Level**	Level Transmitter	1
6	**Tailrace Level**	Level Transmitter	4
7	**TRT Outfall**	Level Transmitter	1

1.6.7.2 Vibration Monitoring System

Vibration monitoring system has been defined in "Generator" Chapter. The Contractor shall make provisions for mounting of probes/transducers at desired location defined below:

i) Two (2) nos. Non-contact type proximity probes at turbine guide bearing to measure radial vibration in both axes,

ii) Two (2) nos. contact type probes at turbine guide bearing housing to measure bracket/housing vibration,

iii) Synchronization probe.

1.6.7.3 Over Speed Device

The Contractor shall furnish a centrifugal type over speed device with provisions for electrical and mechanical tripping, on the shaft of each turbine above the guide bearing. The mechanical tripping device will directly actuate the governor shutdown valve though a hydraulic connection, in case of turbine speed exceeding present limit. It shall be furnished complete with rotating and stationary trip mechanism, guards, connection to inlet valve control, and necessary supports. The mechanism shall be completely mechanical or oil-hydraulic and not dependent on electrical equipment for its operation. However, two electrical independent ungrounded changeover contacts shall be provided for alarm and initiating governor shutdown.

1.6.7.4 Silt Measuring Instruments

The Contractor shall furnish optical on line silt measuring instruments to indicate and record the silt content of the water passing through the tailrace. The silt measuring instruments shall be capable of measuring instantaneous silt content in parts per million (ppm) by volume, with error not to exceed +/- 2 %. Output shall be indicated on digital indicator, with an output compatible for IEC 61850 or IEC 60870-5-104 protocols.

1.6.7.5 Ultrasonic Flow Measurement System

Each turbine shall be provided with an ultrasonic flow measurement system in the penstock or spiral case extension, for continuous on-line monitoring of flow through the turbine. The required ultrasonic transducers shall be permanently installed in the water passage for each unit. The equipment shall be as per IEC 60041. The flow metering system shall drive data from eight (8) sets of transducers paths or more, to achieve the accuracy.

The flow meter system supplied shall include all the equipment and interconnecting wiring required to measure the flow rate and design head for display.

1.6.7.6 Hard Coating

As the project is situated in Himalayan region due to which underwater parts of the turbine might get eroded on account of high silt laden water as per the clause 4.2.1.3 of GTP, it is envisaged to have suitable repairable HVOF hard coating on the water bearing surfaces on the areas as per below:

i) **Nozzle**

a) Nozzle Seat Ring/Liner/Insert Ring (High water pressure area).

b) Needle Tip/Spear complete (Water surface area).

c) End Cap.

d) Inside surface of Nozzle Mouth Piece complete.

ii) **Runner**

a) Bucket concave surface and Root area complete.

iii) **Deflector**

a) Deflector part, exposed to high water pressure.

The bidder shall submit complete technical detail of the coating, process of coating, proven performance, the agency where from the coating process is envisaged, the coating thickness, chemical composition and other maintenance aspects of the items which have been coated. It would be better, if the coating is repairable

Further details in regard to the facility/possibility of carrying out such coating at site shall also be submitted. In case of otherwise in respect of any component due to its weight or size or any other constraints, the details in respect of the same shall also be submitted. Minimum thickness of the hard coating is envisaged to be 500 micron or more. The bidder must quote the item wise prices as detailed in Price Schedule.

1.7 Runner Repair Facilities

Contractor shall recommend suitable in-situ or at site runner repair facilities to be created, to ensure that runner repairs are fast, or good quality and with minimum stresses on account of welding. With this in view, Contractor shall consider and offer as an optional item:

i) MIG/MAG Welding Machine,

ii) Special air electrically operated grinders required for runner repair,

iii) Suitable arrangement for pre & post-heating requirement and runner buckets for in-situ repairs, including controlled preheating and cooling arrangement,

iv) Test set for detection of runner cracks,

v) Suitable templates for profile check after repairs.

Necessary details or arrangement offered shall be supplied. Contractor shall also furnish detailed procedure to be adopted for runner, needles and nozzle seats repair, welding. Preheating-post heating/stress relieving, welding finishing etc. at site.

1.8 Tests

1.8.1 Shop Assembly and Tests

The details of test to be performed at Shop are given in Model Quality Assurance Plan. Besides model QAP, the contractor shall also perform the following tests:

1.8.1.1 Assembly

The turbine distributor, runner housing and bearing, needle and deflector control system (including the oil pressure piping) runner shaft, deflector and needle servomotors shall be completely assembled, aligned, and fitted in supplier's shop, and properly match-marked to ensure correct reassembly and alignment in the field.

1.8.1.2 Turbine Hydrostatic Test

The spiral distributor shall be tested for a period of 30 minutes under a hydrostatic pressure not less than 50% above the maximum normal pressure in the shop after manufacture.

1.8.1.3 Servomotor Cylinders and Oil Pressure Systems

The servomotor cylinders and oil pressure system shall be subject to a pressure test of 50 % above maximum normal pressure, for a period of 30 minutes. After being tested, the equipment and piping shall be thoroughly cleaned and protected. Leakage test shall also be performed.

1.8.1.4 Bearing Cooling System

The heat exchanger shall be tested for a period of 30 minutes under a hydrostatic pressure of not less than 1.5 times the rated pressure. The bearing oil tank shall be shop assembled and filled with a light solvent; allowed to stand for one hour and observed for leakage. The bearing oil tank shall be shop assembled and filled a light solvent; allowed to stand for one hour and observed for leakages.

1.8.1.5 Guide Bearing Test

Turbine guide bearing performance and withstand type test shall be performed.

1.8.1.6 Operational Tests of Needles

Operational test of needles comprising the following shall be done:

i) Alignment and free movements of needle,

ii) Needle opening by actual stroking of servomotor,

iii) Nozzle oil leakages.

1.8.1.7 Static Balancing of Runner

Static balancing of runner shall be performed in the shop. The supplied runner shall be statically balanced prior to shipment in accordance to ISO-1940/IG6.3 or equivalent standard.

1.8.1.8 Turbine Shaft Run Out Test

Run out check of turbine shaft shall be performed in the shop.

1.8.1.9 Tests on Sub-Assemblies

Tests on sub-assemblies to verify fits or alignment, proper functioning, radiograph, magnetic particle, dye penetrant, or ultrasonic inspections shall be performed as required by good standard practice. A list of sub-assemblies and tests proposed for quality checks shall be submitted.

1.8.1.10 Material Tests

Material tests for important components such as runners, needles, shaft, distributor, deflector and other important components shall be done.

1.8.2 Defects and Corrections

Any leakage, distortion, or other defects developed during or after the tests shall be corrected and retested. The tests shall be repeated after repairs, if in the opinion of purchaser further tests are necessary.

1.8.2.1 Record of Shop Measurements

A record shall be made of shop measurements of all critical dimensions, diameters, concentricity's, run-outs, clearances, etc. of the turbine moving and stationary parts, which may affect the field erection and alignment or normal operation of the turbine. Before dispatch of equipment, five (5) complete sets of these records shall be forwarded to the purchaser for reference during field erection and for record purposes.

1.8.3 Field Tests

All field tests including operational, pre-commissioning and commissioning tests shall be conducted by the Contractor, in the presence of the representatives of the Employer.

Procedure to be adopted for conduction the operational, pre-commissioning, commissioning, performance and field acceptance tests shall be submitted well in advance, at least six (6) months before start of relevant testing, for approval of the Employer.

1.8.3.1 Tests during Installation

i) **Distributor Assembly**

The distributor, nozzle and needle shall be assembled together and pressure tested at 50% above the maximum design pressure before concreting. Pressure shall be maintained for 30 minutes without falling. There should be no leakage from needles. Pressure shall be maintained while pouring concrete to detect the leakage if any, from any piping or fittings connected with the distributor.

The Supplier shall furnish one (1) set of test equipment for site hydrostatic testing of individual distributors. This equipment shall include one (1) pressure pump and one (1) bulkhead with bolts, nuts and gaskets for closing off the turbine inlet during hydrostatic test at the site. Bulkhead and accessories and test equipment will remain the property of the purchaser and cost of these shall be included in Tools and Devices offered against para 2.10.

ii) **Calibration**

Calibration of needle/deflector openings including their relationship and measurement of clearances.

iii) **Testing of Protective Devices**

Testing of protective devices i.e. oil level, temperature, pressure, over speed, alarms, tripping etc. including adjustments, if any.

iv) **Turbine Bearing**

Heat exchanger shall be subjected to a pressure of 1.5 times the rated pressure for 30 minutes.

Bearing oil tank shall be tested for oil leakage with light solvent.

v) **Hydrostatic Pressure Test**

Hydrostatic pressure tests, leakage tests and operational tests on sub-assemblies, auxiliaries motorized and other valves, piping system, to the extent feasible shall be done.

vi) **Operational Tests**

Control logic field tests to prove control logic scheme for operation and interlocks of auxiliaries, including annunciation and shutdown scheme shall be done in so far as practical.

vii) **Calibration Test**

All instruments, gauges, sensors, switches, temperature relays, and similar equipment shall be calibrated and adjusted after installation, wherever practical. Where not practical, the calibration and adjusting shall be done just prior to installation.

Operation of unit up to 130% rated speed may be necessary to adjust speed relay provided in governor.

1.8.3.2 Pre -Commissioning Tests

i) Tests to check all weld joints done at site.

ii) Shaft and guide bearing clearances.

iii) Clearances of labyrinth assembly.

iv) Shaft rotational checks for alignment.

v) Tests to determine opening and closing time of deflector and needle servomotors.

vi) Tests to determine needle stroke characteristics and to ensure that these characteristics are identical and in conformity with design. Deflector servomotor characteristics shall also be determined. Suitable transducers shall be used to record the characteristics.

vii) To determine deflector v/s needle operating characteristics, to ensure that for small load changes, deflector does not enter jet, while for large load changes, deflector acts to deflect the jet.

viii) All the pre-start tests as detailed in Cl.6.1 and 6.2 of IEC: 545.

ix) Bearing run test to determine temperature rise of bearing, to determine maximum bearing temperature at no load and maximum overload condition.

x) Load rejection tests at 25, 50, 75 and 100 percent rated load and at overload (110 %) to verify speed rise and pressure rise.

xi) Unit starting, stopping, braking, no load no excitation run test, part load, full load and overload operational tests to ensure performance as per specifications.

xii) Measurement of vibrations during various operating conditions.

xiii) Braking time from 120/100 percent speed to 20 percent speed under brake jets operation.

xiv) Any other checks/tests to ensure that requirements of the specifications are being met. No extra charges for such tests shall be payable.

1.8.3.3 Commissioning Tests

All applicable tests listed in IEC Guide for Commissioning, Operation and Maintenance of Hydraulic Turbines (Publication 545) shall be carried out in accordance with specified procedures. These shall include but not be limited to the following:

i) Deformation of covers and bearing supports,

ii) Noise/ vibration in turbine,

iii) Water supply pressure for bearing,

iv) Turbine safety and signal devices,

v) Operating condition of all pumps,

vi) Oil levels, temperature, pressure, cooling water temperature etc.

vii) Shaft run out at turbine and generator bearings,

viii) Brake jet operation,

ix) Load run and load rejection test,

x) Time - RPM Deceleration Curve

Time-rpm deceleration curve without excitation on the generator from rated speed to 10 % speed.

xi) **Operational Test of Over Speed Device**

Over speed device shall be subjected to necessary test and check for spherical valve closing at present turbine over speed.

xii) **Index Test**

Index test shall be performed on each unit to calibrate the flow meter within 0.2 percent accuracy, to assess change in efficiency during operation, and to optimize power output.

1.8.3.4 Devices and Instruments for Tests during Erection and Commissioning

All devices including special devices and instruments required for testing of turbine components, sub-assemblies and auxiliary equipment during erection and commissioning shall be supplied by the supplier. This shall also cover the bulkhead, test ring etc. for pressure testing of spiral distributor. A tentative list of such special tools and devices shall be supplied by the supplier. A detailed list of items shall be furnished at the design stage.

1.8.3.5 Field Acceptance Tests on Turbine

Tests for general acceptance and efficiency/output will be done by supplier as soon as possible after the equipment has been placed in operation. In the event it is necessary to place the equipment in regular service for a considerable period of time, before the acceptance tests are made, the equipment will be inspected carefully and so far as possible restored to its original condition by purchaser before tests are conducted.

Test Instruments

The supplier shall provide all necessary instruments and equipment required to determine the turbine efficiency at site by Thermodynamic or alternate acceptable method. These instruments will remain the property of the supplier.

Test Codes

Unless otherwise mutually agreed to in writing, acceptance tests with be conducted in accordance with the latest edition of the “International Code for the Field Acceptance Tests of Hydraulic Turbines" (IEC-41).

Test Supervisor

Purchaser may contact for the service of an independent test supervisor, experienced and skilled in the art of conducting turbine efficiency tests.

Independent Agencies and their Charges

For conducting field acceptance test, the supplier shall recommend names of a few independent agencies with a good experience in the field and indicate their charges separately for consideration of the purchaser. The quotation shall include hire charges of equipment, to and fro transit and other incidental expenses. Rates of test engineer, for efficiency test, shall be quoted on per day basis. Number of days, and number of persons, for which services of test engineer shall be required shall be mentioned in the offer.

Provision

The Supplier shall make all necessary provisions (such as pick-ups, embedded connections, etc.) on all the four turbines, for the efficiency test, at no additional cost to the purchaser.

Procedures

Procedure to be adopted for conducting the commissioning and field tests shall be submitted well in advance and shall be subject to approval of the purchaser.

Runaway Speed Test

At the option of the purchaser, the turbine shall be given a runaway speed test for a period of 2 (two) minutes to demonstrate ability to withstand successfully the mechanical stress and hydraulic performance incident to maximum runaway speed at maximum head conditions.

1.8.4 Test Report

Shortly after the completion of the field acceptance tests the Contractor shall prepare and forward draft copies of the field acceptance tests report to the employer for review. After review an acceptance, the Contractor shall furnish six (6) copies of the final reports.

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1.9 Drawings, Documents and Design Calculations

1.9.1 Design Memorandum

The Contractor shall submit to Employer a design memorandum prepared in accordance to clause 2.5 "Design Memorandum", of General Technical Specification.

1.9.2 Drawings and Documents

The Contractor shall submit all the drawings and documents in accordance with requirements stipulated in clause 2.6 "Drawings & Documents to be supplied by Bidder" of General Technical Specification.

1.9.3 Design Calculation

The Contractor shall submit the design calculation in accordance to clause 2.6 of General Technical Specification covering at least the following, for review/ acceptance:

i) Stress analysis of runner, nozzle and its servomotor, deflector and its servomotor, distributor assembly and pit liners,

ii) Stress analysis of turbine shaft and coupling bolts,

iii) Critical speed and bearing arrangement,

iv) GD2 calculations,

v) Hydraulic transient analysis including speed and pressure rise,

vi) Natural frequency of the unit,

vii) Heat exchanger/temperature rise calculation for turbine guide bearing.

viii) Calculation of foundation loads under various normal and most abnormal operating conditions for turbine components.

1.9.4 Instruction Manuals

The supplier shall prepare manuals covering the information and instructions pertaining to the following sections for guidance during storage, installation and operation & maintenance.

1.9.4.1 Manual for Storage, Preservation and Handling at Site

This manual shall contain detailed information about the system of marking adopted to show sling points, restrictions regarding position of transport of any package & position of application of any cradle provided for use during transport or site storage/preservation of goods for all items. Four (4) copies of such manuals shall be submitted to the purchaser:

1.9.4.2 Manuals for Erection, Testing and Commissioning

This document shall include full and detailed instructions regarding the procedures and precautions to be observed during erection of turbines and associated accessories including the use of erection equipment. It shall also include the performance parameters required to be met during erection to demonstrate that the equipment erected is within the tolerance specified in the contract.

The testing and commissioning section shall include full detailed directions for the methods & procedures to be followed, the parameters to be observed & recorded in checking the accuracy of erection and carrying out site tests as required under the contract. It shall also include the performance parameters required to be met for site tests, description of all equipment & instruments provided for these tests and of their use. Four (4) copies of such manuals shall be submitted to the purchaser:

1.9.4.3 Manual for Operation & Maintenance

This shall include complete instructions for operation and maintenance of turbines and associated equipment not only during the defect liability period but also during its operating

life. The directions shall be set out simply, clearly and systematically as per clause 2.11 of General Technical Specification.

1.10 Schedule of Similar Installation

The bidder shall furnish a list of similar type and of similar or higher rating equipment supplied and duly installed & commissioned by him along with the bid. The bidder shall furnish the place and the year of supply and their commissioning dates along with the particulars of equipment supplied.

1.11 Delivery, Installation and Commissioning

The Contractor shall follow the general requirement of Delivery, Installation and commissioning as per relevant clauses in General Technical Specification.

1.12 Schedule of Requirement

The schedule of requirements of major equipment and essential services shall be as per various clauses in the foregoing and the supplier shall be responsible to ensure completeness of supplies and services even though these are not fully covered under this clause. No additional charges shall be payable for the items not explicitly listed but are found essential.

Broad schedule of requirements for turbines and accessories comprises of the following:-

Any item of supply not explicitly listed but otherwise either implied by the contents of the specification or essential for smooth operation of the equipment shall be construed as forming part of the supply and no additional charges shall be payable for the same.

As and when any particular item/s which was not explicitly listed are found to be essential, the contractor shall affirm the inclusion of the same in the scope of supply without any extra charge.

Sl. No.	Items	Units	Qty.
1	152.3 MW (or matching with corresponding generator output of 150 MW), 375 rpm, 6 jet Pelton Turbines including all components, accessories and equipment.	Nos.	4
2	Instruments, gauges, transducers and temperature detectors for turbine.	Sets.	4
3	Spares for turbine.	Set	1
4	Hydraulic brakes.	Sets	4
5	Special tools, slings, jigs, fixtures and devices necessary for erection, dismantling and re-assembly, testing and commissioning.	Sets	1
6	Piping and fittings within and surrounding the turbine pit associated with turbine.	Sets	4
7	Nameplates.	Sets	4
8	Consumables like welding electrodes for Site welding and lubricating oil for bearings, grease etc. for initial filling of the system plus 10% extra in each case.	Set	1
9	In-situ runner repair tools/facilities including runner profile templates.	Set	1
10	Equipment's like bulkhead, pump etc. for hydrostatic testing of distributor.	Set	1
11	Other general tools including wrenches, tools and special equipment for assembling and dismantling of turbines.	Set	1
12	Hydraulic quantities measuring devices, headwater and tail water level indicators, turbine flow meter device and net head on turbine.	Set	1
13	All power, control & special cables, cable glands, lugs, terminals, connectors etc. required for completion of work	Lot	1

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Sl. No.	Items	Units	Qty.
14	Complete installation, maintenance and operation manuals for the major equipment and all accessories.	Nos.	7
15	Model testing of turbine in the manufacturer's works or test house.		
16	Shop assembly and testing of turbine components as specified.		
17	Field acceptance test of turbine and required test equipment and instruments as specified.		
18	Detailed design of all the work including furnishing of drawings, reports, computation sheets, and design calculations, templates of runner and other parts for site repair and other data as required.		
19	Copies of all test reports as specified.		

1.13 Spare Parts

Recommended spare parts shall be supplied in accordance to clause 3.0 "Spare Parts and Tools" of General Technical Specifications. Mandatory spare parts to be supplied under this Chapter are as follows.

Sl. No.	Description	Unit	Qty.
1	Runner complete with fixing bolts.	Nos.	2
2	Set of coupling bolts and keys (if applicable) Runner to Turbine shaft along with one set of Template for Runner Bucket measurement	Set	1
3	Coupling bolts turbine shaft to generator shaft	Set	1
4	Turbine guide bearing segments/ pads complete set	Sets	2
5	Set of six needle tips, gaskets, nuts & bolts, packing, etc. and renewable seat ring	Sets	4
6	Nozzle including needle servomotors	Sets	2
7	Deflector including servomotor	Sets	2
8	DTT (Dial Type Temp/ Thermometer) thermometer of each type	Nos.	4
9	RTD (Resistance Temperature Detector) of each type	Nos.	10
10	Water flow meter/ switch of each type	Nos.	2
11	Pressure gauges of each type	Nos.	2
12	Pressure switch / pressure transmitter of each type	Nos.	2
13	Oil level gauges of each type	Nos.	2
14	Valves of size 80 mm and above including penstock drain valve	1No. of each used type	

One set defines total quantity used in one turbine.

Besides above, the Contractor shall recommend any additional spare parts, which in his opinion are necessary for satisfactory operation of the system. However, the procurement of these recommended spares shall be at the discretion of the purchaser. The additional recommended spare parts shall be indicated in the Data Sheets of Volume-6.

1.14 Guaranteed and Other Technical Particulars

The Contractor shall follow the Guaranteed & Other Technical Particular requirements specified in Data Sheets of Volume-6.

1.15 Tools and Instruments

The Contractor shall supply all necessary tools and Instruments etc. for installation, repair and maintenance in accordance to clause 3.2 "Tools and Instrument" of General Technical Specification.

1.15.1 Special Tools

The Contractor shall list and supply all special tools. List of such tools including their make and detailed specification, shall be submitted for acceptance by the Employer. The proposed list of special tools must include the following in addition to tools recommended by manufacturer(s):

i) One (1) Set Motorized runner handling trolley, rail etc. for transporting the runner inside and outside of runner discharge pit.

ii) Two (2) sets of Alloy steel wenches of Size M20 to M100 mounted on a wrench board or in a tool cabinet,

iii) Two (2) sets each of Alloy steel open headed spanners and socket wrenches of Size M20 to M100 mounted on a board or in a tool cabinet,

iv) Two (2) sets of Alloy steel combination ring and open end spanner of size M20 to M100 mounted on a board or tool cabinet,

v) Two (2) sets of Alloy steel open headed slogging spanner of size M20 to M100 mounted on a board or tool cabinet

vi) Two (2) sets of Torque wrenches covering torque range up to 350 N.m.

vii) One (1) set of hydraulic torque tensioners with two identical tensioners operated by a common power pack for runner/ turbine shaft flange coupling bolts, as per applicability.

viii) One (1) set of hydraulic torque tensioners with two identical tensioners operated by a common power pack for turbine shaft/ generator flange coupling bolts

ix) One (1) set of hydraulic wrenches for each type of bolt size viz. head cover, runner cone bolts, etc. used in the plant.

x) One (1) Complete set of Stainless steel templates and its drawing (including face, outer and inner profile, W-section/cutout, thickness, longitudinal and transverse depth profile). The references for measurement must be clearly indicated on the template and drawings.

xi) One (1) set of stainless steel deflector templates

xii) Two (2) sets of different size of Nylon Sling - round, for handling head cover, shaft, runner, servomotor, TGB and other turbine components

xiii) Two (2) sets of different size of Nylon Sling - Flat, for handling head cover, shaft, runner, servomotor, TGB and other turbine components

xiv) Four (4) no. of Eye Bolts of each size (M10, M20, M24, M30, M36, M42, M48, M50, M56) for handling of turbine components

xv) Four (4) no. of D- shackles of each size (1T, 2T, 5T 10T, 20T, 25T for handling of the turbine components.

xvi) One (1) set of Turbine Guide bearing dismantling and handling devices.

xvii) One (1) set Pump, bulkheads and other devices for hydrostatic testing of distributor, coolers etc.

xviii) One (1) set of special tools and tackles required for handling/mounting of nozzle servomotors and deflector assembly.

xix) Two (2) set of special tools and tackles required for replacement of needle tips, nozzle seats, deflector etc.

xx) One (1) set of Runner Lifting device

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xxi) Two (2) sets of Special tools for disassembling and assembling of Nozzle injector assembly (for nozzle servomotor seals replacement and servicing)

xxii) Two (2) sets of Special tools for disassembling and assembling of deflector (for deflector servomotor seals replacement and servicing)

xxiii) Two (2) sets of Heavy duty special tools for runner shear bush/pin insertion and removal

xxiv) Any other hydraulic/impact wrenches, tools and devices recommended by manufacturer for large size bolts, i.e. runner, distributor, and dismantling flanges bolts etc.

1.16 Quality Control and Assurance

The Contractor shall submit detailed Quality Assurance Plan and Inspection Schedule for Employer's review and approval in accordance to clause 12.0 of General Technical Specification.

1.17 Deputation of Engineers for Witnessing of Shop Tests, Inspection and Training

The Employer's representatives shall be deputed for the following purposes:

Sl. No.	Description	Batch	No of Days	No. of Engineers and Technicians
1	Training at the plant and design office for important components including maintenance and assembling	2	5	4 Engineers 6 Technicians
2	Witnessing of turbine model test	1	5	3 Engineers
3	Shop Inspection and Test	As and when required for inspection and test		

Note: Training component is inclusive of Main Inlet Valves and Butterfly Valves

The training of employer's personnel shall be as specified in clause 11.0 "Training of Employer's Personnel" of General Technical Specification.

1.18 Deviations from Specifications

All deviations from these specifications shall be separately listed in the requisite Performa of the bid document, in the absence of which, it will be presumed that the provisions of the specifications are fully complied with by the bidder. However, the deviations, which are better than the specifications shall be considered by the purchaser.

1.19 Completeness of Contract

Any fittings, accessories or apparatus required for successful commissioning though may not have been specifically mentioned in the specification but are usually necessary for the completeness of the works shall be deemed to be included in the specification and shall be supplied by the bidder without any extra cost to the purchaser.

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1.20 Employer's Specification

Sl. No.	Item	Particulars	Description
1	**Turbine and Accessories**		
1.1	Type of turbine		Six Jet Vertical Pelton Turbine
1.2	No. Of units		4
1.3	Design MW rating (at generator terminals) of each Unit	MW	150
1.4	Constant Speed / Variable Speed		Constant speed
1.5	Continuous minimum load output	MW	6% of rated output at generator terminals at rated head operation
1.6	Hydraulic conditions		
i)	Full Reservoir Level (FRL)	m	EL. 1572.00
ii)	Minimum Draw Down Level (MDDL)	m	EL. 1558.00
iii)	PMF Level at TRT outfall	m	EL. 761.50
iv)	Maximum Tail water level at PH end	m	EL. 768.00
1.7	Net Head		
i)	Maximum	m	766.2
ii)	Design / Rated	m	761.5
iii)	Minimum	m	752.2
1.8	Elevation of powerhouse (Maintenance Bay)	m	EL. 784.00
1.9	Turbine centreline elevation	m	EL. 772.50
1.10	Speed of turbine	RPM	375
1.11	Water conductor system		
i)	Head race tunnel		
i)	No. of. Head race tunnel		1 No
ii)	Type of tunnel		Horseshoe
iii)	Diameter of tunnel		5.7 m
iv)	Length of tunnel		15.77 kms
ii)	Surge shaft		
i)	No. of. Shaft		1 No

Sl. No.	Item	Particulars	Description
ii)	Type		Circular Steel lined
iii)	Diameter of Shaft		9.5 m
iv)	Height of Shaft		152.8m
iii)	Pressure shaft		
a)	Pressure shaft		Circular Steel Lined
b)	Number of Pressure shaft		2 No
c)	Diameter of Pressure shaft		3.30 m
d)	Length of Pressure shaft		1535 m each
iv)	Penstock		
a)	Penstock		Circular Steel Lined
b)	Number of Penstocks		4 No
c)	Diameter of Penstock		2.35 m
d)	Length of Penstock		187 m each
v)	Tail Race Tunnel		
a)	Numbers diameter & shape		D shape (1 No. 6m (W) x 6m (H)
b)	Length of tunnel		1591 m
c)	Unit TRT's		4 No's, 3.5m (W) x 6m (H) D-Shape
d)	Length		605.19m Long
1.12	Maximum permissible speed rise		Less than 20%
1.13	Maximum permissible Pressure rise		Less than 15%
1.14	Critical speed (% run away speed)	%	Shall not be more than 180% of the rated speed (Withstand at least 30min without cooling water flow)
1.15	Materials of construction		
i)	Runner (Full Forged)	Stainless Steel, 13Cr-4Ni,	ASTM A 743 Gr CA 6NM / GX4 Cr Ni 13-4, EN 10283
ii)	Turbine shaft (Forged)	Stainless steel	ASTM A 668 Cl D / E / F / P355QH1, EN 10222-4
iii)	Coupling bolts	Alloy steel NiCrMo	ASTM A 434 Class BD

Sl. No.	Item	Particulars	Description
iv)	Turbine housing	Carbon steel	ASTM A516 Gr 60/70 / S355J2+N, EN 10025-2/ IS 2062 E350B0
v)	Pit Liner	Carbon steel	ASTM A 516 Gr. 60 / 70 / IS 2062 E250B0
vi)	Distributor	Carbon steel	ASTM A516 Gr 60/70 / S355J2+N, EN 10025-2/ IS 2062 E350B0
vii)	Nozzle Body	Carbon steel	ASTM A516 Gr 60/70 / S355J2+N, EN 10025-2/ IS 2062 E350B0
viii)	Needle	Stainless Steel, 13Cr-4Ni,	A 473 UNS S41500 / ASTM A276 Gr. 410 / A473 Gr 410 / ASTM A 240 SS 304L / ASTM A 473 S41500 / ASTM A 473 S41500
ix)	Nozzle Seat Ring	Stainless Steel, 13Cr-4Ni,	
x)	Deflector	Stainless Steel, 13Cr-4Ni,	
xi)	Nozzle & deflector servomotor	Carbon steel	ASTM A 537 Class II
xii)	End cushioning for Guide vane servomotor		
2	**Governor**		
2.1	Type of Governor		Digital
2.2	Type of Governor control		Hydraulic
2.3	Governor oil pumps		
i)	Number (W + SB)	Nos.	2 (1W + 1SB)
ii)	Type		Variable displacement / gear pump
2.4	Pressurized oil storage system		
i)	Type		Nitrogen Piston type
ii)	No. of strokes of guide vane and turbine inlet valve required without the oil pumps running		2 Strokes (C-O) of Nozzles servo motors
2.5	Hand pumps for black start		
2.6	Oil Pressure relay		

Sl. No.	Item	Particulars	Description
2.7	Oil sump level switch		
2.8	Sump oil temperature switch		
2.9	Oil pressure signal failure switch		
2.10	Speed Signal failure switch		
3	**Cooling Water System**		
3.1	Type		Horizontal Centrifugal Pump
3.2	Applicable standards		As per manufacturer
3.3	Pump casing material		Carbon steel / Cast Iron
3.4	Impeller		Stainless Steel
3.5	Pump Shaft		Stainless steel
4	**Filters**		
4.1	Type		Automatic Duplex Filter
4.2	Applicable standards		As per manufacturer
4.3	Filter Cleaning Microns		As per Design requirement
4.4	Filter Element material		SS 304

CHAPTER 2: DIGITAL GOVERNING AND ACCESSORIES

2.1 Scope of Work

Scope of work under this Chapter covers the provision of labor, tools, plants, materials and performance of work necessary for the design, manufacture, quality assurance, quality control, shop assembly, shop testing, delivery at site, site storage and preservation, Insurance, installation, commissioning, performance testing, acceptance testing, training of the Employer's personnel, handing over to Employer and guarantee for three years of four (4) sets of digital electro-hydraulic governing system, as per the specifications hereunder, each complete with all auxiliaries, accessories, spare parts and warranting a trouble free safe operation of the installation. The Systems shall be suitable for Ambient, Seismic, Altitude and other site conditions mentioned in General Technical Specifications.

The scope of work shall be a comprehensive functional system complete in every respect including but not be limited to following:

2.1.1 Digital Electronic Controller

i) Four (4) sets of fully redundant digital electronic controller unit consisting of following main components:

   a) Digital micro-processor, (32 bit or more),

   b) PLC unit for Control logic and signal I/O,

   c) Power supply,

   d) Terminal cards,

   e) Relays for digital outputs,

   f) Signal converters,

   g) Communication facilities with control system,

   h) Other accessories for governor electronics.

ii) Governor shall be designed considering the requirement of Indian Grid code & Bhutan Grid code whichever is stringent

iii) Color human machine interface terminal for each unit to perform local supervision and control of the governor and its auxiliaries.

iv) All hardware and software required to make program changes including a mobile workstation.

2.1.2 Oil Pumping Unit

i) Four (4) sets of oil pumping unit consisting of following main components:

   a) All associated valves such as distributing, proportional, control, emergency shutdown, check valves including other types, piping, fittings etc.

   b) Dual oil filtration unit with changeover facility along with clogging indication,

   c) Oil sump tank,

   d) Motor driven main and standby oil pumps mounted on the sump tank,

   e) Motor driven jockey oil pump mounted on the sump tank,

   f) Oil pressure accumulator with associated accessories,

g) Instrumentation such as pressure gauges, pressure switches, pressure transducer, moisture indicator, temperature gauges, temperature switches, level transducer, level gauges, level switch etc. required for the system,

h) Cooling system, if required,

i) Other required accessories,

ii) Four (4) sets of Nitrogen based oil pressurization units along with Nitrogen bottles.

2.1.3 Miscellaneous Components and Auxiliary System

i) Four (4) sets of transducers/ sensors/ devices along with necessary connections/ interfaces for measurement of:

a) Frequency,

b) Nozzle and deflector position,

c) Unit power output,

d) Speed,

e) Opening limitation.

ii) All other necessary items/ equipment's/ provision for synchronous condenser mode operation.

iii) Coordination and provision of necessary contacts and/or ports compatible to IEC 61850/IEC 60870-5-104 for integration with plant SCADA system.

iv) Four (4) sets of interconnecting cables, terminations etc. between various parts of the equipment/components.

v) Four (4) sets of all types of pipes, fittings, valves including mechanical/ electrical control for oil, water and nitrogen circuits.

vi) Oil for first filling of governor with 10% extra quantity, in non-returnable drums, for all four units.

vii) Spare parts in accordance to clause 2.11 of this chapter.

viii) Tools and Instruments in accordance to clause 2.13 of this chapter.

ix) One (1) lot of power, control & special cables and cable glands, lugs, terminals, connectors etc. for cabling of equipment and devices covered in this chapter.

Any other item(s) not mentioned specifically but necessary for the satisfactory completion of scope of work defined above, as per accepted standard(s)/best international practices.

2.1.4 Main Characteristics

The four Pelton turbines are to be equipped with electronic governors, which shall comply with IEC publication No. 308.

The governors are to be equipped for the following operation modes:

i) Automatic start up and shutdown operation

ii) Power controlled operation under stable network conditions

iii) Frequency controlled operation under isolated network conditions

iv) Operation within a network with frequency and power control

v) Water level regulated operation

2.1.5 Instrumentation

i) Level measurement in the governing nitrogen/oil pressure tank (" too high level" –"high level"- "set level"-"sufficient level"-"insufficient level"-"low level" – "too low level

ii) Limit switches "governing air/oil pressure tank isolation valve open & closed respectively

iii) level measurement in the oil sump tank ("too low level" – "low level" – "too high level"),

iv) PT100 for extreme regulating oil temperature

v) Pressure measurement to detect set pressure in the governing oil circuit

vi) Set of pressure switches to monitor the governor OPU pressure, pump change over and loading and unloading.

vii) Level measurement in oil sump of pressure oil supply system

2.2 Special Design and Layout Conditions

2.2.1 System Arrangement

The governing system, individual for each unit, shall be of the digital programmable electronic type of proven design. The digital electronic controller shall be fully redundant with hot standby feature. All equipment shall be suitable for continuous duty and interchangeable between the units. Each governor shall have joint control facility, a speed sensing element, pressure system, oil piping, shutdown and speed no-load solenoids, oil pressure and all parts and accessories required to constitute a complete automatic assembly for regulating the speed, load and controlling the nozzle and deflector with which it is to be used.

The governor shall, in combination with the turbine automatic control system, enable the control of the valves, start-up and standstill sequences.

The hydraulic components shall be equipped with pressure oil accumulator in order to guarantee for the pump's safe shutdown of the turbine operation in case of an energy supply failure.

The protection devices of the turbine automatic equipment are to be arranged into two main functions as follows:

i) The emergency shutdown function,

ii) The quick shutdown function.

The quick shutdown function stops the generating set via electrical impulses in the predefined standard order (closing of nozzles, disconnection of generating set at no load, closing of the turbine inlet valve, brake nozzles opening until complete stop of the generating set, etc.).

In case of the emergency shutdown function, the generating sets are brought to a standstill via electrical impulses by activating the stop-functions immediately and simultaneously (closing of nozzles, generating set to be disconnected from grid, closing of the turbine inlet valves, activating the jet deflector, etc.)

All the generating units shall be operated in parallel and each unit shall be capable for operation under isolated network conditions.

The governor shall be complete with all necessary devices for complete automatic and remote control, synchronizing and supervisory load frequency control and shutdown. Local control such as nozzle opening limit, nozzle control (Servo position control), and speed and load adjustment shall also be possible from local governor panel and unit control boards.

Governor shall be fail-safe on the failure of the speed-sensing element, loss of oil pressure or defect in the actuating system so that under any of these conditions, the machine shall be automatically shut down, with alarm and indication.

The speed sensing element shall be capable of causing the governor to pass oil in the direction to effect corrective movement of the nozzle in consequence of a speed variation of less than 1/100 of 1 percent.

The Governing system shall be designed suitably for automated and continuous operation of the units in Synchronous Condenser Mode Operation also. All transfer among the modes can be bi-directional and shall be in lowest possible time. Necessary logics, control elements and interfacings shall be provided accordingly.

Governor shall use PID (Proportional Integral Derivative) loop control in which three derivatives of speed are used for speed stabilization.

2.2.2 Fail-Safe Provision

Digital programmable electronic type governor shall be design on the basis of fail-safe principles. Governor shall be fail-safe on the failure of the speed-sensing element, loss of oil pressure, loss of power supply or defect in the actuating system so that under any of these conditions, the machine shall be automatically shut down, with alarm and indication.

2.2.3 Power Supplies

A reliable power supply shall be provided for powering the governor electronic circuits. The power supply for the governor shall be from two independent DC station battery source, one as primary and other as secondary. Switchover from primary to secondary shall follow automatically on failure of primary and return to the primary source automatically following restoration of primary supply.

The power supply shall include redundant converter (dc-dc) connected to station battery source such that failure of any regulated output voltage shall cause instantaneous transfer to a redundant converter without affecting normal governor operation in any way. Contacts shall be provided to alarm on power supply failure and local indication shall be provided to identify the failed functional block. The Contractor shall provide full details of the proposed power supply system for approval by the Employer.

In case AC supply is required for any control function, same shall be sourced from two on line UPS, with one main and other standby and with automatic change over facility.

2.2.4 Transient Immunity

The governing system shall be immune from false operation or failure from high voltage, high frequency transients that may be conducted in the control circuitry and power supplies internal and external to the governor system.

To reduce the transients coupled from external sources, shielded cables shall be used for connection to the external equipment and surge suppression devices shall be installed on inductive devices. Special precautions shall be taken to limit exposure of sensitive governor electronic circuits connected to remote equipment. These circuits shall be isolated by means of solid state optically coupled or transformer coupled isolation amplifier. All inductive devices, such as relays and solenoids shall be provided with suppression devices to limit surge voltages that may be generated when the coil circuits are interrupted. The governing system shall be designed and tested for surge withstands capability in accordance with applicable ANSI/IEEE Standard. The governing system shall be designed and tested to be insensitive to radiated high frequency interference such as that coupled from portable radio transmitters.

2.2.5 Electronic Equipment

All electronic equipment such as amplifier and logic circuits shall be of solid state design using industrial grade discrete integrated circuits, bearing JEDEC or EIA registered device numbers. All components shall be suitable for operation at temperatures between (-5) °C and 70°C.

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2.2.6 Test Facilities

The governor shall be provided with software tool allowing dynamic recording (similar to oscilloscope) of governor internal test point. The output of each functional block within the electronic portion of the governor shall be accessible from this tool. The controls shall be arranged to permit the electronic circuits to be tested and replaced while the turbine- generator unit is in service.

The test facilities software shall also allow quick maintenance including functions such as parameters display, modification, saves and retrieve, input and output display.

2.2.7 Actuator Lock

An automatic locking device shall be supplied that shall cause the turbine control mechanism to lock at its last position in the event of speed sensor failure, power failure, removal/failure of electronic component or operation of other protective devices. The device shall allow the turbine control servomotors to close under action of the servomotor limit and automatic shutdown devices.

2.2.8 Hydraulic System

The governor hydraulic system shall perform in accordance with the requirement of this specification, using oil of same specification as used for lubrication of generator thrust bearing and turbine bearing.

Dual filter set with changeover along with clogging indication shall be provided to ensure that impurities above the allowable limits as per the manufactures are avoided.

2.2.9 Software Program Features

The software for the digital governor shall be capable of quick program running. In case of any power supply failure the program and parameters shall remain indefinitely retained.

The governor shall have auto test program for checking permanently for correct operation of the main governor components. The correct execution of the software shall also be permanently checked for which suitable self-monitoring and diagnostic features/ Watchdog functions shall be provided.

The software shall prohibit the programming of the parameters beyond the allowed values. The Programming/logic functions/ parameters, in no cases, shall go into freeze mode during normal operation.

2.2.10 Maintenance/Replacement Provisions

The digital governor shall have modular construction with suitable configuration to enable quick and easy maintenance/ replacement in case of faults. The maintenance operation of the digital governor shall be feasible by use of an automatic internal checking program and also step by step manual internal checking program with the help of instruction manual. .

2.2.11 Emergency Shutdown Valve

An emergency solenoid valve shall be provided which shall operate in emergencies and catastrophic conditions so as to operate the deflector and close the nozzle independently of any action of the governor.

2.3 Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS)/International Standards as given below except where modified and/or supplemented by this specification.

Sl. No.	Description	Standards
1	Guide to specification of hydraulic turbine control systems	IEC 61362

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2	International code for testing of speed governing systems for hydraulic turbines	IEC 60308
3	IEEE recommended practice for preparation of equipment specifications for speed-governing of hydraulic turbines intended to drive electric generators	IEEE 125
4	IEEE guide for the application of turbine governing systems for hydroelectric generating units	IEEE 1207
5	Code for unfired pressure vessels	IS - 2825
6	Unfired Pressure vessels	ASME SEC VIII Div. 1

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted subject to approval of the Employer. In such case, copies of the English version of the standards adopted shall have to be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules, Central Electrical Authority's rules and regulation as amended up to date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

2.4 Rating and Functional Characteristics

2.4.1 Rating

The digital governor shall be capable of performing at least the following functions:

i) Speed control,

ii) Power control,

iii) Turbine creep detection,

iv) Control sequencing,

v) Isolated and Islanded modes of control,

vi) Interface with control system for remote control of unit from the control room at the powerhouse or from remote location. The governor shall have interface compatible to IEC 61850/ IEC60870-5-104,

vii) Loading optimization,

viii) Joint control of all the four (4) units,

ix) Level control,

x) Flow control,

A bump free switch over between above modes shall be acceptable. The speed governing of the generating unit shall be carried out by a combination of proportional, integral and differential actions and non-liner characteristics in order to provide best quality of control.

The digital governor shall have high sensitivity, quick response to speed/load changes, least possible dead band time and wide adjusting ranges as given below in respect to various parameters.

Sl. No.	Characteristics	Limits/Range
1	Sensitivity speed	Not more than 0.01 % of rated
2	Range of speed changer adjustment	Adjustable between (-) 5 Hz and (+) 5 Hz of normal 50 Hz (90% to 110 %)
3	Permanent speed droop	Adjustable between 0-10 %
4	Temporary speed droop	Adjustable between 0-100 %

5	Speed dead band at rated speed	Shall not exceed 0.02 percent of the rated speed at any nozzle opening. The dead band adjustment shall be 0 to +-3Hz.
6	Governor dead band time	0.2 sec for step load change of 10 % of rated load or more
7	Deflector time to cut off the jets for runner under full load	Adjustable up to 2 sec.
8	Nozzle closing time	Adjustable up to 20 secs. (to be confirmed and matched with turbine chapter)
9	Nozzle opening time	Adjustable up to 30 secs.

2.4.2 Governor Time Adjustment

i) The governor shall be designed to operate the turbine deflector in less than 2 secs and shall be capable of being adjustable for operation up to a maximum of 2 secs.

ii) The governor shall be designed to operate the turbine nozzles through a full nozzle closing stroke in not less than 5 seconds and shall be capable of being adjusted for operation up-to a maximum of 20 seconds to ensure that speed rise and pressure rise do not exceed the prescribed limits.

iii) The nozzle adjustments shall positively restrict the oil flow and shall be arranged to prevent movement of the nozzles at a faster rate than the maximum rate of which the adjustment is set.

iv) The minimum time from zero RPM condition of machine to 100 % loading shall be 8 (eight) Minutes.

2.4.3 Capacity

The rating/capacity of the hydraulic system of the governing system shall not be less than the capacity of the servomotors for operation of the deflectors and nozzles. The governor shall be capable of supplying sufficient oil to the servomotors to operate the turbine deflectors and nozzles to give an effective time from a complete closing or opening stroke for the range of operating times, with a minimum oil pressure under the maximum net head on the turbine. The maximum oil velocity in the pressure pipes lines shall not exceed 3 m/s and 1.5 m/s in return lines. The governor oil pressure system shall be designed for the extreme case of closing, opening and final closing of the nozzles with both oil pumps and nitrogen/oil system inoperative.

2.5 Performance Criteria and Guarantees

The Digital governing system along with all auxiliaries and accessories shall be capable of performing intended duties under specified conditions and Data Sheets. It is the responsibility of the Contractor to supply the equipment as per guaranteed technical particulars and shall also guarantee the reliability and performance.

2.5.1 Stability Criteria

The governing system shall be capable of controlling, in a stable manner, the speed of turbine between 90 % and 110 % of rated speed of the turbine at all power outputs between zero and maximum power output inclusive when the generating unit is operating isolated, or the power output when generating unit is operating in parallel with the other generators connected to the system.

The range of conditions covered by stability requirements shall include sustained conditions, load rejection, and sudden changes of isolated load, both large and small.



2.5.1.1 Sustained Conditions

The steady-state governing speed band (also called speed stability index) under either speed-no-load or loaded conditions shall not be more than 0.3% with the unit operating at 5% speed droop or speed regulation.

The steady-state governing load band (also called power stability index) shall not be more than 0.4% with the unit operating at 5% speed droop or power regulation.

2.5.1.2 Load Rejection

Following rejection to zero of any load within the capability of the governed unit, speed shall be returned close to the speed reference as may be modified by speed droop or regulation, with no more than one under speed deviation exceeding 5% and one over speed deviation exceeding 5% subsequent to the initial over speed deviation.

2.5.1.3 Load Ramping Performance

With the governor, in speed reference control mode, controlling the turbine with the generator connected to a large power system, adjustment of the speed changer (speed/load level) shall result in ramping of the nozzle position set point signal at an adjustable rate between 5 seconds and 500 seconds.

Governor shall be designed for ramping up the unit from zero RPM condition of machine to 100 % loading within 8 Minutes

2.5.1.4 Isolated and Islanded Mode of Operation and Control

- **Isolated Mode of Operation and Control**

The generating units (4 x150MW) of KHEP shall be connected directly to 400 kV and 132 kV grid and shall operate in parallel and also be capable for operation under isolated network conditions.

Isolated mode of operation shall happen when generating units are isolated from the grid, feeding a separate bulk of local load. The governor shall be able to regulate and control the speed/frequency for an isolated load.

Auto-switchover to isolated mode of operation shall happen when the generating units are isolated from the grid, feeding a bulk of load. There shall be an isolation detector that automatically places the governor into isolated mode for smooth control.

- **Islanded Mode of Operation and Control**

Islanded operation is similar to isolated operation, with the exception that the frequency of the islanded system is impacted by the performance of all or few of the interconnected generating units and loads within the “island” of operation. When the power system undergoes a major cascading disturbance that may split up the system into electrical “islands,” speed governors are the only control devices that can control and maintain the frequency within acceptable deviations. Therefore, governing system shall be suitably tuned for good stability under these conditions and shall perform well in islanded mode of operation.

Due to the various requirements of the different operation modes, the governor shall have bump-less switching characteristics in order to provide safe and preserving operation.

2.5.2 Automatic Synchronizing

For the purpose of aiding automatic synchronizing, the governor shall be equipped with speed matching features. The grid frequency may be derived as speed reference.

2.5.3 Power Transducer Failure

In case of failure of power transducer, the governor should automatically transfer the mode of operation to position control mode. An alarm should be raised.

2.5.4 Turbine Shutdowns

A safe and orderly shutdown should be executed for the following conditions:

i) Failure of the governor controller's main CPU,

ii) Failure of all power supplies,

iii) Failure of all speed signals,

iv) Failure of main control actuator position transducer,

v) Failure of nozzle control actuator position transducer,

vi) Nozzle control actuator position mismatch,

vii) Governor oil pressure critical low,

viii) Oil temperature critical high,

ix) Sump oil level critical low,

x) Accumulator oil level critical high,

xi) Accumulator oil level critical low,

xii) Over speed.

2.5.5 Stability Studies

The Contractor shall simulate, using appropriate methods, the interaction of penstock, turbine, generator, load, excitation system and governor in order to determine the best governor parameters for operation under isolated network and interconnected network. The study shall prove that the system is stable under all load conditions when adequate adjustments of the governor parameters are set and the pressure and transient speeds after load rejection are within the specified limits when the deflector and nozzle closing time is appropriately adjusted. The stability studies shall cover the operating range between maximum and minimum net heads with the discharge corresponding to the full load under each respective net head. Studies shall be conducted for conditions including parallel operation with an infinite system, supply of an isolated resistive load, and supply of isolated loads with special speed regulation characteristics specified. The studies shall indicate the setting range of the governor parameters for which the control circuit remains stable after any disturbance. The quality of regulation shall be demonstrated in diagrams indicating the transient response of the frequency of the isolated system to load variations (increase and decrease) for various net heads and the transient response of power for changes of the speed or generation changer when supplying an infinite system.

2.6 Design and Construction

2.6.1 Type and Description

The governor controls for the hydraulic turbines shall be of servo-based oil-pressurized digital-electronic-hydraulic type. The fundamental speed-governing functions including speed sensing, development of the governing control signal, its modification with stabilizing terms, insertion of speed changer signal (speed/load level), and speed droop shall all be developed digitally. Physical control of the turbine deflector and nozzle servomotors is to be accomplished hydraulically. The transmission of control from the governor electronics to the turbine deflector and nozzle servomotor system shall be in the form of a deflector and nozzle position set point signal. This nozzle position set point control signal shall be electronic. The nozzles are to be controlled by the hydraulic servomotors via electro-hydraulic interface and feedback system so as to correspond exactly to the position called for by the governor nozzle position set point signal.

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The governor controls and auxiliary equipment shall be of a type having an established reputation for satisfactory and reliable hydroelectric service, and their operation shall be guaranteed by the Contractor.

The unit governor controls shall be complete with electro-hydraulic interface with the digital controls, a speed signal generator (SSG) device for providing speed sensing for speed-rated switching functions and tachometer indication, interconnecting oil piping, wiring, instrumentation, controls, and indicating devices with all parts and accessories required to make a complete unit for regulating the speed and controlling the nozzle opening of the turbine.

All panels that are provided shall be hinged so that they may be easily swung open to give ready access to all electro-hydraulic components and control devices.

Each governor shall be capable of interfacing with automatic synchronizing equipment and be adaptable for Automatic Generation Control (AGC) through direct interaction with the SCADA system.

2.6.2 Electronic Cubicle

2.6.2.1 General

All electronic components of digital governor shall be housed in an electronic cubicle. The cubicle shall be a dust tight steel cabinet with doors for convenient adjustment, test and maintenance and shall be mounted at a suitable location along with unit control board panels. The cabinet shall meet the following requirements:

i) Be NEME type 12,

ii) The cubicle thickness shall be 2mm. The protection class of the panel shall be IP54 or more,

iii) Size of panel's internal wiring shall be as per manufacturer's standard practice,

iv) Have a rack type support system and an auxiliary standoff panel at the rear of the cabinet,

v) Have doors with three point latches. The doors shall be provided with gaskets and locking handles,

vi) Have an interior LED light operated by a light switch,

vii) Have suitable locks with triplicate and master key for locking and opening all panels,

viii) Have one duplex 20 amps, 240 Volts A.C, 3 wires grounded type plug receptacle,

ix) Have an internal wire gutter system with removable covers,

x) Have sufficient terminal blocks to accommodate all circuits with approximately 20% spare terminal points,

xi) Have means to support cables leaving bottom of the cabinet,

xii) Have interior surface of the cabinet and auxiliary mounting panels that are painted white,

xiii) No terminal shall be provided in 300 mm bottom space. Gland plate at bottom shall also be provided,

xiv) Built-in test circuits and instruments shall be provided to check all circuits,

xv) Parameterization facilities for adjustment of various governor setting including speed droop setting shall be provided.

2.6.2.2 Main Governor Cubicle

The main governor cubicle shall provide speed and load control function. Speed and Load control function shall be P&ID type with speed droop, corresponding parameter shall be adjustable within the following range:

i) Permanent speed droop : 0 <bp<10%

ii) Proportional action gain : 0.1<kp< 20

iii) Integral action time : 0.1 <Ti <20s

iv) Derivative action time : 0.001<Tn <5s

v) Derivative action gain : 1<kd<10

Suitable logic shall be built in the system for various modes of operation viz. speed control, power control, flow control, level control, islanded/isolated control etc. Whenever a fault occurs in any modes in which it is operating, it shall change over to any possible option or shut down the unit.

Further logics shall be in built in the system to change the offline parameters (P&ID) to "on line" parameters on detection of closing of generator circuit breaker. And also, provision for changing P&ID parameters shall also be made through internal detection of the unit running under isolated network conditions or interconnected network.

2.6.2.3 Digital Electronic Controller

The digital controller shall have provisions for setting / adjusting and indication display of the set values of various governor characteristics/ parameters with the help of the keyboard/HMI viz.

i) Permanent speed droop,

ii) Temporary speed droop,

iii) Temporary speed droop decay time constant,

iv) Sensitivity,

v) Frequency,

vi) Dead band,

vii) Speed regulation,

viii) Power regulation,

ix) Opening limitations,

x) Speed set point,

xi) Output set point,

xii) Monitoring and supervision of speed, power and position feedback signals,

xiii) Other essential devices for smooth operation protection and safety of the units.

The governor shall be fitted with a feed forward or ramper device to improve the time of response of the generating unit to changes in load adjustment. This device shall allow load adjustment commands to bypass the normal proportional, integral and derivative amplifiers.

2.6.2.4 Digital Micro Processor

The governor microprocessor shall have the following capabilities:

i) **Speed**:

The microprocessor shall be able to simultaneously run the frequency and speed transducers, the main speed control algorithm, and the actuator control system with an

update rate of 10 milliseconds or less. It shall also be able to run all other processors simultaneously with an update rate of 10 milliseconds or less. The processor loading shall be less than 90% while running all specified tasks.

ii) **Program Memory:**

The processor program shall be stored in non-volatile memory, so that the program shall be saved indefinitely with no external power applied to the processor board. All governor memory shall be parity memory that shall generate an alarm on failure.

iii) **Failure Detector:**

The governor shall have a failure detection feature that immediately initiates operation of the governor shutdown and lockout relay upon processor malfunction.

iv) **Programming:**

The processor shall be capable of being programmed at the governor without any additional equipment in a high-level language using ladder logic or block diagrams.

Microprocessors used shall continuously monitor the following:

i) Programmed sequence checks (watch dog feature),

ii) Status of analog, binary input/ output modules,

iii) Positioning circuits etc.

All hardware and software required to make program changes shall be provided including a mobile work station having Quadra Pro processor, 3.5 GHz or latest available at the time of approval, HD-DVD (High definition DVD writer), 500 GB hard drive, 8 GB of RAM (expandable up to 20 GB), 56.6 Kbps internal modem, 17" viewable LED monitor and all required cables and software to program the digital governor controller.

v) **Communication Interface**

The communication interface for Governing System shall be compatible to IEC 61850/ IEC 60870-5-104.

2.6.2.5 Speed Sensing Devices

Speed of the unit for governor operation shall be measured both from the remnant voltage of the generator, taken at the potential transformers and by inductive transducer actuated by toothed wheel located on the generating unit shaft.

These two fully independent speed sensing systems shall be installed as main and back-up respectively, with automatic switch-over in case of loss of signal of the main system.

The toothed wheel type speed signal generator (SSG) mounted on the generator shaft and a magnetic pick-up mounted near the toothed wheel shall provide a redundant source of speed signal for the governing system. This output shall also be used for detection of creep and shall have the provision for an alarm to apply brakes and supply HP lubrication oil. The speed signal generator shall be complete with toothed wheel and magnetic pick-up and internal wiring up to the terminal box on the generator barrel shall be carried out.

If either speed signal fails or goes out of range, an alarm shall be generated and control shall be transferred to the other signal without affecting the normal operation of the governor. If both speed signals fail, immediate closure of the turbine gate servomotors to the shutdown position and an immediate operation of the governor shutdown and lockout relay shall occur in automatic mode.

The capacity and characteristics of the SSG shall fully match with the requirement of speed responsive elements and governor regulation and control system. It shall be designed to withstand satisfactorily the maximum runaway speed of the turbine.

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2.6.2.6 Power Measurement

Governor main control cubicle shall include one power transducer to measure generating unit active power. The power transducer shall be connected to generator outlet PT's and CT's.

2.6.2.7 Speed Control

The governor shall be capable of executing the following:

i) To start the unit from zero to rated speed. To allow a smooth operation particular nozzle limitation shall be involved during the starting sequence,

ii) To maintain the unit frequency close to the grid. The difference between grid and unit frequencies shall be adjustable from 0.2 to 0.02 Hz,

iii) To adjust unit speed between 90% and 110% of nominal speed. Suitable ramping function shall be provided,

iv) The automatic unit speed no load shall be controlled by the PID circuits of the governor to match it always with the nominal frequency and ensure the speed stability under no load conditions,

v) Pure speed control mode shall be inhibited after synchronization of the unit to the grid.

2.6.2.8 Power Control

In power control mode the speed governor shall adjust generated power to the set point:

i) Received from the control system in remote mode (selected on the local control panel),

ii) Internally generated from order received from the local control panel in Local Mode.

The operation mode "Power Control" can be selected only when the units are running in parallel (Unit circuit breaker is closed). Further if there is any frequency deviation from the rated value, Frequency compensation shall be active adjusted by the Speed droop. (Frequency/Power Droop)

The Power controller set point shall be adjustable between 0 &100 %.

2.6.2.9 Opening Control

In opening control mode the speed governor shall adjust nozzle opening to the set point:

i) Received from control system in remote mode (selected on the local control panel),

ii) Internally generated from order received from to local control panel in Local Mode.

The operation mode "Opening Control" can be selected only when the units are running in parallel (Unit circuit breaker is closed). Further if there is any frequency deviation from the rated value, Frequency compensation shall be active adjusted by the Speed droop. (Frequency/Power Droop).

Selection between opening control and power control shall be made on the local control cubicle. Opening control shall be automatically selected if power measurement is not available.

2.6.2.10 Speed Droop

The permanent speed droop shall be adjustable between '0' and '10' percent. Adjustment shall be easily accessible for operator.

2.6.2.11 Opening Limitation

The main governor shall be provided with nozzle opening limitation (OPL) function.

During starting and synchronization, internal opening limitation shall ensure smooth operation of the unit.

After connection to the grid, the opening limitation can be adjusted from 0 to 100% according to set point:

i) Received from control system in remote mode (selected on the local control panel),

ii) Internally generated from order received from to local control panel in Local Mode.

Internally generated opening limitation according to water head signal shall protect the unit from operation in over-opening zone. This limitation is a backup of the power limitation function. This limitation can be modified by operator.

2.6.2.12 Power Limitation

The main governor shall be provided with active power limitation function, internally generated according to water head signal to protect the unit from operation in over-power zone. This limitation can be modified by operator.

In case of power signal failure, this limitation shall be disabled.

2.6.2.13 Speed Relays/Switches

A digital tachometer module with suitable number of speed thresholds shall be mounted in the main cubicle of the governor. The tachometer module shall be able to measure speed of turbine with two (2) redundant inductive transducers mounted and toothed wheel.

Speed switches shall be easily adjustable.

These switches shall enable governor to detect the following speed threshold:

i) **Over Speed Protection:**

   a) To cause emergency shutdown of the unit through certain specific protection circuits and/or when unit speed increases beyond 110 %.

   b) To cause unit shut down through shutdown solenoid via protection circuits at and above 120 % of rated speed.

   c) In the event of catastrophic conditions and speed rising to 140 % and above, simultaneous command to go to emergency solenoid valve and the MIV control cabinet for closure.

ii) **Excitation 'ON'**: Two sets of contacts shall be arranged to close at and above 90 percent of the rated speed.

iii) **Brake control**: To activate the generator brake when the unit speed is approximately 30 percent of rated speed.

iv) **Creep & stop detection; Zero speed:** To close the contacts at zero speed indicating unit stopped.

v) **Start/Stop of H.S. Lubricating pump.**

vi) **Two spare thresholds.**

In addition, speed signals 4-20 mA and any speed threshold which may be required for control system such as automatic brake application, starting and stopping of HS lubrication pump and any other application shall be available.

2.6.3 Communication with Control System

Communication of Governing System with Unit Control System and Station Control System (Plant SCADA) shall be done exclusively through IEC 61850 or IEC 60870-5-104 protocols.

2.6.4 Governor Local Control Cubicle

The local control panel includes the Servo Position controller, colored HMI, redundant 220V DC power supply, terminal block, output relay, display meter of Nozzle position & Limiter and all necessary switches for manual control of the nozzle.

2.6.4.1 Servo Position Controller

The servo position controller shall control the nozzle position in both Auto and Manual Mode.

In Auto mode, the servo position controller shall receive nozzle position set point through a high-speed local area network (LAN).

In manual mode, the nozzle position set point shall be internally elaborated from order available on the local control panel door.

The servo position control function shall be P&ID type with double close Loop.

2.6.4.2 Nozzle/Deflector Redundant Transducer

The Linear Transducer for feedback of nozzle/deflector position shall be mounted on each servomotor to get 100% redundancy.

The transducer shall generate 4-20mA signal proportional to the stroke of servomotor.

2.6.4.3 Manual Mode

The Manual Mode shall be selected by using Auto/Manual selector switch and Position adjustment using Raise/Lower opening switch from the front door of the Local Control Panel. Transfer between normal governor control and manual mode should be accomplished smoothly, without a disturbance in the actuator position.

2.6.4.4 Nozzle Freeze

In case of fault of the main speed governor such as speed sensor failure, power failure, removal/failure of electronic component or operation of other protective devices the local nozzle control device included in the governor local cubicle shall freeze the nozzle position and continue generating. The nozzle can be adjusted locally or by remote until unit circuit breaker remains closed.

2.6.4.5 Control and Indication

The following control indication and display meter, but not limited to, shall be provided on the local governor cubicle:

i) Indication

a) Main power supply ON,

b) Standby power supply ON,

c) Servo position controller minor and major fault.

ii) Control

a) Manual Position Mode ON/OFF,

b) Manual position raise/lower switch.

iii) Display Device

a) Nozzle position,

b) Nozzle position limiter.

iv) HMI

The local control cubicle is equipped with HMI, touch screen type mounted on the front door. In addition to above control and indication, HMI shall provide following indication, control and parameter setting function.

1) Indication

i) Test point indication such as speed, frequency, power, limitations, nozzle position etc.

ii) Logic information (I/O signals)

iii) Alarms & Faults (Current and historical).

2) Control

i) Auto/Manual control,

ii) Local//remote control of governor,

iii) Switching from one control mode to another.

3) Parameter Setting (Protected by Password)

i) User Parameter setting,

ii) Communication port setting,

iii) Data such as speed, opening, setting etc.

iv) Setting of parameters used for speed & power control,

v) Diagnostics.

4) Indicating Lights

The following indicating lights shall be mounted on the front face of the local cabinet / Unit control board

i) Servomotor gate lock "On" or "Off" indication,

ii) Generator brake switch in "Auto" position,

iii) Generator brake "On" or "Off" indication,

iv) Actuator lock "On",

v) "Auto"/"Manual", light on to indicate "Auto" or "Manual",

vi) Speed sensor failure indicating light,

vii) Governor electronics power supply test and failure indication,

viii) Inlet valve position, full open and full closed positions.

At least the following analogue meters shall be duplicated at UCB (in addition to HMI of Governor):

i) Unit power output,

ii) Speed,

iii) Nozzle position/nozzle limit position.

2.6.4.6 In addition to above, the following controls and instruments shall also be included in the governing system:

i) **Nozzle position and Nozzle limit control and indication**

A mechanical nozzle limit indicator and nozzle position indicator shall be provided on local control panel. These indicators shall be designed for field adjustment to obtain correct indication of turbine nozzle position.

Manufacturer shall supply current transducers and wiring in the cabinet for remote indication of nozzle position and nozzle limit at the powerhouse control room and unit control board.

The nozzle limit control device shall limit the extent of nozzle opening at any position within the full range of nozzle travel. The control device shall be suitable for manual adjustment locally from local governor cubicle, unit control board and remote adjustment from powerhouse control room through SCADA system.

ii) **Speed adjustment control and indication**

A device for adjusting the speed set point of the governor when the generator is isolated from the system shall be provided, operated manually at the cubicle and electrically controlled by the unit synchronizing equipment.

The control device shall be suitable for manual adjustment locally from local governor cubicle, unit control board and remote adjustment from powerhouse control room through SCADA system.

The speed changer position shall be displayed on an indicator located on governor at the local cabinet and on the unit control board.

The provision for speed adjustments shall be provided for use in the control as per the requirement.

iii) **Load adjustment control and indication**

A device for adjusting the output set-point of governor when the main breaker is closed, and the unit is synchronized with the system shall be provided. A feedback selector switch shall be provided to supply the load adjustment control with a feedback signal from either the nozzle opening or generator output load. Provision shall be made for easy selection between the two feedback signals in the field.

iv) **Manual Nozzle control**

It shall be possible to manually control the nozzles from the control cabinet for local control for testing and in order that the unit can continue in operation should the electronic circuitry, transducer or transducer pilot valve be inoperative. Transfer of control shall be possible from automatic to manual control and vice versa while the unit is in operation.

Manual or automatic control shall be selected using a solenoid controlled from the actuator cabinet or from the remote-control system at the unit control board and in the powerhouse control room. Automatic shutdown protection shall be available under manual control also.

v) **Automatic start, shutdown and speed-no-load**

A device to automatically start the turbine, shut down the turbine, and for emergency and catastrophic shutdown of the turbine or operation of automatic protection devices for the generator, turbine and governor, shall be provided.

The automatic speed-no-load device, when actuated, shall limit the turbine nozzles to slightly above the speed-no-load position. This device shall be designed to permit manual or automatic shutdown of the unit to speed-no-load at any time and shall be such that the nozzles are again governed by the speed responsive element on reaching the speed-no-load position.

The automatic start-up (from the powerhouse unit control board, control room or remote control) shall be initiated by momentary closure of contacts. Synchronizer action shall then be initiated from the governor when the unit attains 90 percent of the speed. Automatic shutdown shall follow momentary closure of contacts (from the powerhouse control room or remote control).

Energize an alarm circuit on low air supply pressure.

vi) **Oil pressure gauge/switch**

A pressure gauge shall be mounted on the pressure tank/ sump tank, graduated in bars, to indicate the pressure in the governor oil pressure accumulator. Also, pressure transducer shall be provided for remote pressure display.

vii) **Governor Balance meter**

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An indicating voltmeter, connected to measure the input to the main electro-hydraulic transducer, shall be provided on the governor cabinet. The voltmeter shall indicate the degree of misbalance or error between the desired servomotor position computed by the electronic circuits and the actual servomotor position, for effecting bumpless transfer from manual to automatic governor control.

2.6.5 Over Speed Device

The contractor shall furnish a centrifugal type over speed device with provisions for hydraulic and mechanical tripping, on the shaft of each turbine above the guide bearing.

The tripping device shall directly actuate the governor shut down valve though a hydraulic connection, in case of turbine speed exceeding pre-set limit. It shall be furnished complete with rotating and stationary trip mechanism, guards, connection to inlet valve control, and necessary supports.

The device shall meet the following requirements:

i) The mechanism shall be completely oil hydraulic and not dependent on electrical equipment for its operation. However, two electrical independent ungrounded change over contacts shall be provided for alarm and initiating governor shutdown,

ii) The rotating mechanism shall be designed for mounting on the turbine shaft at a suitable place. It shall preferably be of the fly ball weight designed acting against a compression spring. The entire rotating mechanism shall be statically balanced,

iii) It shall be set to trip at approximately five percent above full load rejection over speed. It shall have a reasonable adjustment range above and below this speed.

2.6.6 Nozzle Control Hydraulic Assembly

The nozzle control hydraulic assembly includes actuator (proportional valve), associated valves, emergency shutdown valve and 2nd closure time control valve mounted on a single manifold to form a complete and operational hydraulic control system for interfacing with the digital servo position controller.

Hydraulic components shall be designed to have Long lifetime, limited maintenance and be suitable for 24-hours-a-day operation and shall have the following minimum provisions.

2.6.6.1 Actuator

The actuator shall consist of electrically controlled proportional (pilot) valve. The proportional (pilot) valve shall be capable to operate the turbine nozzle servomotors through a full opening or closing stroke at the minimum normal operating oil pressure and minimum time specified.

The actuator control system shall position the turbine servomotors to equal the set-point output signal from the digital controller. The actuator control system shall be designed in a failsafe manner such that loss of either its power source or its set-point signal shall cause an immediate closure of the turbine gate servomotors to the shutdown position with full squeeze and an immediate operation of the governor shutdown and lockout relay.

Position feedback from each turbine servomotor shall be from a highly reliable, non-contacting type position transducer. Redundant feedback shall be provided with a fully independent position transducer system located on each of the turbine unit gate servomotors employing separate conduit routing to separate analog inputs at the governor processor. Each transducer shall be mounted as close to the turbine servomotor as is possible in order to minimize errors introduced by mechanical connections. If the connection to the servomotor is under tension to eliminate backlash in the transducer system, it shall be arranged such that breakage of this connection shall result in a closure of the nozzles.

A position feedback mismatch detection function shall be provided with an adjustable threshold (of 0 -10 percent in 0.1 percent steps). If the mismatch between the position feedback transducers exceeds the threshold, this function shall cause an alarm, but not affect the normal

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operation of the governor. If either position feedback fails or goes out of range, an alarm shall be generated and control shall be transferred to the other transducer. If both transducers fail or go out of range, an immediate closure of the turbine gate servomotors to shutdown position with full squeeze and an immediate operation of the governor shutdown and lockout relay shall occur in automatic mode.

2.6.6.2 Dual Oil Clean Filter

Dual oil clean filter with changeover and clogging indication devices shall be provided in the oil circuit.

2.6.6.3 Emergency Valve

An emergency solenoid valve shall be provided which shall operate in emergencies and catastrophic conditions and able to close the nozzle servomotors independently of any action of the electric governor.

2.6.6.4 2nd Closure Law

The governor closing time having dual rate of closure shall be established to restrict the pressure rise and speed rise within specified limits mentioned in "Chapter 1 - Turbine and Accessories".

2.6.6.5 Gate Position Switches

Minimum three nozzle switches shall be installed on servomotors at a suitable location for easy maintenance to detect:

i) Full open position,

ii) Full close position,

iii) Speed no load position.

These switches shall be used by control system for operating sequence. Speed no load position switch shall be easily adjustable. Contacts shall be electrically separated, ungrounded, and suitable for 220 V DC.

2.6.7 Oil Pressure System

2.6.7.1 General

Each unit shall have an independent oil pressure system serving the turbine nozzles for operation of the governor for the operating mechanism, servomotor and controls. The oil pressure system shall consist of a sump tank, two (2) A.C. motor driven screw pumps and one jockey pump of suitable capacity, if required and pipes, fittings etc.

The design shall be compact, and there shall be easy access to all the components for maintenance and replacement. All the components shall be selected to assure high reliability, long life, low noise and minimum heating of the oil.

2.6.7.2 Operating Pressure

The normal operating pressure of the oil pressure system shall be 100 - 120 bar and medium shall be nitrogen/oil.

2.6.7.3 Oil Pumps

Mounted on the oil sump tank, two oil pumps shall be provided, one acting as "main" and the other as "standby". Each oil pump for the oil pressure supply system shall be independently driven by a 3-phase 415V AC electric motor and each shall have a capacity sufficient to operate the complete governor and MIV oil pressure system. A complete pump logic control system shall be provided that shall permit the selection of either pump, as the main unit with the other pump acting as a standby, which shall cut in automatically to supply the oil and close a set of alarm contacts.

One jockey pump mounted on the sump tank, if required shall also be provided. Each pump shall have following devices/ provisions:

i) At the outlet, one electrically controlled loading/unloading valve so that it discharges to the sump at reduced pressure or accumulator. It shall be possible to run one main pump continuously without overheating the oil,

ii) At the outlet, one safety valve which shall be adjusted to open at more than the maximum operating pressure as per manufacturer's recommendation and shall be sized to pass the pump full flow with pressure increase less than 10 %,

iii) At the outlet of the pump, hand operated valves to permit isolating of pumps from the oil pressure,

iv) In the suction line, a suitable oil strainer.

Each main and standby oil pump shall be of the screw type/variable displacement axial piston type, with a capacity (l/ minute) of not less than 1.5 times of the total active oil volume of both the servomotors per minute or higher when operating under the pumping pressure recommended by the Contractor. Each pump shall be self-priming under maximum oil pressure.

Jockey pump shall be of the screw type, with a capacity not less than two (2) times of the total internal leakage when operating under the system pressure. Jockey pump shall be self-priming under maximum oil pressure.

Each pump shall be direct-connected to a 415 V, 3 phase, 50 Hz, squirrel- cage, low starting current, induction type motor designed for full voltage across the line starting and conforming to IEC standards, with class F insulation. The motor shall have windings with moisture and oil-resistant insulation. The windings shall be braced for line start application. The capacity and torque shall be suitable for the pump requirements. The jockey pump shall run continuously.

The pumps operation shall be as follows:

i) No load starting by returning the oil flow through an unloading valve,

ii) In normal operation, jockey pump shall run permanently and keep the pressure within the operating limits by closing and opening the unloading valve,

iii) In case of pressure drop, the main pump shall start, restore the pressure and then stops,

iv) In case of excessive pressure drop the standby pump shall start, both main and standby pump running together shall restore the pressure and then stop,

v) In case of failure of main pump, the standby pump shall automatically be considered as main,

vi) In case of failure of the jockey pump, the main pump shall run permanently and keep the pressure within operating limit by closing and opening the unloading valve,

vii) Automatic changeover from main to standby on the basis of pre-set running hour.

All valves and mechanisms shall be accurately set and tested in the shop before delivery.

A manual control switch shall be provided to select one of the two pumps as the lead pump. An alarm shall be provided to indicate continuous running of the lag pump over on adjustable period of time.

The unloader valves shall be operated from the pressure accumulator pressure by pilot lines, complete with isolating valves and filters or by pressure switches and shall be equipped with "snap" action pilot valves. Hand-operated valves shall be provided to permit isolating pumps from the oil pressure. Adjustable temperature switches with two (2) electrically separate contacts suitable for operation at 220 V DC located in the sump tank for oil high temperature alarm shall be provided.

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The connections to all pumps shall be arranged so that any pump may be removed for repair or replacement without interfering with the continuous operation of the system.

2.6.7.4 Oil Sump Tank

The governor system shall be supplied with a sump tank of sufficient capacity to hold at least 10 percent more than the total quantity of oil in the entire governor system including oil pressure accumulator. The sump tank shall be designed and have connections for venting and overflow.

The sump tank shall be provided with a manhole of 500 mm diameter with a suitable oil-resistant gasket for access to the interior of the tank. A suitable oil level glass shall be provided to indicate the level of the oil in the tank, marked with low and high level marks, complete with both hand shut-off valves and automatic means of shutting off oil discharge in the event of breakage.

Suitable connections for filling and draining the tank, and connections for an oil purifier shall be provided. The oil purifier connections shall consist of two pipe outlets and valves, one located near the bottom on one side and the other near the top on the opposite side. A vertical filter screen shall be arranged to divide the sump tank into "clean" and "dirty" oil compartments.

All strainers shall be readily removable for cleaning. The outlets of all oil pipes to the sump shall be below low oil level. Any component that requires adjustments shall not be located inside the sump tank. Low and high level switches shall be provided for sump tank, suitable for 220 V DC, which operate alarms whenever the oil level reaches the present level. An oil temperature switch wired to cut off power supply to the oil pumps in the event of high temperature shall also be provided. Moisture indicating devices in oil sump tank shall be provided for moisture indication.

i) **Main Circuit Oil Filtering**

One oil filter shall be provided in the pumps unloading discharge line. Clogging visual indication with electrical contacts to indicate the clogging of filter shall be provided. Filter elements used shall be cleanable with Petrol and easily changeable without affecting the normal operation of the generating units. Main circuit oil filter shall be equipped with one automatic by-pass allowing operation in case of clogging of the filter element.

The filter system shall be able to handle the discharge flow of both main and standby Pumps.

ii) **Cooling System**

One (1) heat exchanger shall be provided to maintain the oil temperature within 50°C. The heat exchanger shall be installed on the unloading return line to the tank and shall be sized for continuous operation of the main pump maintaining pressure between operating limits and to create water temperature increase no more than 4°C. Temperature indicating devices on both sides of coolers shall be provided.

2.6.8 Oil Filtering Unit and Dehydration & Degasification Unit

Four (4) number of oil purifier unit (Electrostatic Liquid Cleaner) for power packs shall be provided to purify the hydraulic oil. It shall be complete in all respect including oil hoses (of sufficient length and size) and hose connector etc. to connect the oil purifier to various equipment/components/ systems. The hydraulic oil purifier shall be electrostatic liquid cleaner type. The capacity of purifier shall be 10-12 lpm. After purification the size of the suspended particle should not be more than 5µm. The oil may contain suspended impurities such as cotton, waste, welding slag and spatters, metallic chips, small sand particles, iron fitting pebbles, dust and scale particles. The oil may also contain grease and kerosene, which shall be required to be removed. The offered equipment shall not be damaged by the flow of oil containing these impurities. Unit shall be supplied along with (5 sets) paper and other consumable required for 5 years of successful operation of machine.

Four (4) number of Low vacuum dehydration & degasification unit for power packs shall be provided to remove water and dissolved gases from the hydraulic oil. The oil may contain free and dissolved moisture of the order of 500 to 600 ppm initially, which needs to be reduced in the range of 50 ppm. The capacity of the vaporizer shall not be less than 50 liters and capacity of vacuum pump shall not be less than 100 LPM.

One unit of contamination checking kit (for checking of contamination level) shall also be provided with the machine.

2.6.9 Oil Pressure Accumulator

2.6.9.1 Capacity

The pressure accumulator shall have a total volume of at least twenty five (25) times the combined active volume of the two gate servomotor cylinders of the turbine and shall be designed for a pressure ten (10) percent above the actual maximum system pressure. The size of the accumulator shall be such that it shall be possible to operate the nozzles 2 times (1 "C" +1 "O") from minimum normal oil pressure without the operation of governor oil pumps and without dry nitrogen admission. At the remaining pressure the governing mechanism should still operate with a safe margin.

2.6.9.2 Construction and Safety Features

The piston type pressure accumulator shall be constructed from plate steel conforming to ASTM A 516 grade 70 or higher in accordance with part UW of the ASME Code for Unfired Pressure Vessels, Section VIII, for the maximum working pressure of the governing system.

An adequately sized manhole of 500 mm diameter, with a suitable oil-resistant gasket of 6 mm Neo-Lancet or equal shall be provided on the pressure accumulator.

The accumulator shall be painted on the inside and on the outside as per approved painting system. Thickness of inside painting shall be such that these do not flake off during operation. Prior to shipping, all threaded openings shall be closed with standard pipe plugs. Flanged openings shall be protected with blind flanges with gaskets bolted in position.

All connections to the pressure accumulator, with the exception of the nitrogen supply and the upper gauge connections etc. shall be made below the low oil level and shall be designed to prevent foaming. Bypass valves shall be provided to drain the accumulator into the sump for cleaning or repairs.

The accumulator shall be equipped with a pressure gauge, a safety relief valve, pressure transducer, burst disc and at least two (2) oil-level sight gauges metallic magnetic float pipe type with indication, switches and transmitter. The safety relief valve shall be set to open at 110 percent of the maximum operating oil pressure of the accumulator. The sight gauges shall be long enough to overlap the high and low oil levels by at least 50 mm. The safety relief valve should release nitrogen to atmosphere in a manner not injurious to personnel or equipment in the vicinity of the accumulator.

The accumulator shall be provided with a float/isolating valve assembly to prevent nitrogen admission into the governor piping system under conditions of low oil level.

The pressure accumulator shall be provided with an automatic nitrogen admission system to maintain a proper proportion of the nitrogen cushion volume. Manufacturer shall supply all necessary piping, fittings, solenoid- controlled valves, pressure and level switches required for this system. The solenoid shall be suitable for operation at 220 V DC and completely wired.

Pressure switches shall be of approved make. In addition to echelon control, the following provisions shall be made for each pressure accumulator.

i) Normal pressure signal for unit start interlock,

ii) Governor oil low pressure alarm to the station annunciator,

iii) Extreme low-pressure trip and unit shutdown interlock,

iv) Automatic nitrogen admission,

All Instruments necessary for proper and safe operation of the unit shall be supplied with at least:

i) One oil pressure transmitter,

ii) One oil level transmitter with switch for normal oil level unit start interlock,

iii) Low level switch – alarm,

iv) Low level switch – Unit trip,

v) Very low level switch – Unit trip and close isolating/ float valve,

In addition to above, one pressure transducer for nitrogen gas shall be installed for monitoring the nitrogen gas pressure through plant SCADA System.

All transmitters shall be 4 to 20 mA type. Contractor is free to use individual suitable pressure and level switches. In this case, all contacts shall be adjustable electrically separate and suitable for 220 V DC operation.

The pipe connections for all pressure and level switches shall be independent of the oil supply lines to the servomotors and shall be provided with individual shut off valves and bleed valves as necessary.

The contractor shall use suitable pressure and level switches of reputed makes/brands as per approved sub-vendor lists. All electrical devices installed on oil pressure unit shall be provided with suitable vibration damper or shall be shock proof as per relevant standards.

2.6.10 Oil Pressure Piping

All pressure piping shall be of seamless stainless steel of minimum schedule 80 except drain pipe which shall be at least schedule 20. The entire piping system shall be welded, insofar as practicable, leaving only such flanged connections as may be necessary for erection or possible subsequent dismantling for repair. Whenever straight pipes are provided, tapered flanged connections shall be introduced to ensure leak proof connection.

The piping shall be thoroughly pickled, acid cleaned, pressure tested, the interior coated with oil and closed before shipment or after site manufacturing.

2.7 Tests

2.7.1 Shop Tests

i) At least following tests shall be conducted in the shop of the manufacturer to verify correct assembly and operation of the complete digital governing system:

   a) Oil sump and associated piping and devices,

   b) Oil pump assembly,

   c) Oil pressure tank (Piston/ Bladder type accumulator),

   d) E.H. governor with distributing valve,

   e) Digital governing cabinet.

ii) The oil pressure tank (Piston/Bladder type accumulator and oil pump casing) shall be given a shop hydrostatic test at a pressure not less than 1.5 times the maximum design pressure, in accordance with section-VIII of the ASME for unfired Pressure Vessel Code.

iii) The pressure tank relief valve setting shall be verified.

iv) The sump tank shall be tested for leakage before painting by filling the tank with water and allowing it to stand for 24 hours and hammering the tank around all weld-deposits.

v) The oil pumps and controls shall be assembled and given an operational test in the manufacturer's shop. All electromagnetic valves and pressure switches shall also be given an operational test.

vi) The governor with controls and the electro-hydraulic actuator shall be assembled in the Manufacturer's plant and shall be given an operational test to demonstrate satisfactory performance. Speed changes shall be simulated and movement of essential governor components shall be simultaneously recorded on a high-speed recorder.

vii) All routine tests on hydro-mechanical and electronic cubicles of governor shall be performed as per latest edition of IEC 60308.

viii) Dielectric and Insulation Resistance test shall be carried out for all the electrical devices.

ix) Shop testes shall be performed on separate main assemblies.

2.7.2 Field Tests

All field tests including operational, pre-commissioning and commissioning tests shall be conducted by the Contractor, in the presence of the representatives of the Employer.

Procedure to be adopted for conducting the operational, pre-commissioning, commissioning, performance and field acceptance tests shall be submitted well in advance, at least six (6) months before start of relevant testing, for approval of the employer.

The equipment/ system shall be considered commissioned and ready for operation only after successful operation for a "trial run operation period" specified in sub clause "Performance Testing". In the event of any failure, this period shall be repeated for any number of times till the successful operation as described above is achieved.

2.7.2.1 Tests during Installation and Pre-Commissioning

Before performing the following tests, all piping and connections shall be thoroughly pickled, acid cleaned, pressure tested and flushed out by pressurized hydraulic governor oil. The system shall then be filled with centrifuged oil before charging:

i) Tightness tests on all pressure oil and gas side piping,

ii) Hydrostatic tests on all pressure oil piping and all pressure piping systems at a pressure 50 % greater than the maximum operating pressure after installation.

iii) Test on oil pressure system to verify:

a) Loading and unloading valve settings,

b) Pressure and level control in oil pressure tank in auto/manual mode,

c) Test to verify pump capacity,

d) Low and high level alarms/shutdown,

e) Low and high pressure alarm,

f) Pressure relief valve setting,

g) Operation of pressure switches,

iv) Tests to verify number of close/open operations with oil pump off.

v) Test to verify logic control scheme from local/remote including start/stop, load control, emergency shutdown, controlled action shutdown, locking and other features.

vi) Calibration of instruments, switches and controllers provided in the governing system, oil pressure system and compressed air systems.

vii) Test to measure nozzle opening and closing times and servomotor cushioning time.

2.7.2.2 Commissioning Testing

i) Tests to verify stability and response of governor for 10% to 20% step change.

ii) Tests to verify governing of turbine during load rejection and load acceptance tests.

iii) Tests to verify performance of microprocessor-based governor regulating and control system.

iv) Test to verify performance of machine on isolated and islanded mode of operations Tests to verify parallel operation of unit as per droop settings selected.

v) Test to verify the Fail-Safe provision in the governing system.

vi) Other test to verify performance as per latest IEC 60308 for testing of speed governing systems for hydraulic turbines.

2.7.2.3 Performance Testing

If nothing unusual has been observed in load run, load rejection tests, and isolated mode of operation test, the Trial Run Operation Period of 72 hours shall follow. During this trial run operation period, the unit must operate continuously at rated condition without any interruption, except those beyond the control of the Contractor. However, such interrupted period shall not be counted for in the trial run operation period.

The Contractor shall be responsible for the equipment during trial run operation and also for the way it is operated. However, Employer's personnel will operate the equipment under the Contractor's presence during the trial run operation period.

2.7.2.4 Field Acceptance Tests

All field acceptance tests in accordance with provision in IEC 60308 shall be conducted at site before acceptance of the digital governor by the employer. These shall include at least the following:

i) Command signal range,

ii) Servomotor capacity,

iii) Permanent speed droop range,

iv) Temporary speed droop range,

v) Permanent speed regulation range,

vi) Deviation time constraints,

vii) Servomotor response time,

viii) Dead bands,

ix) Dead time,

x) Other applicable tests as per IEC-60308;

xi) Verification of identical characteristics of nozzle servomotor opening/closing,

xii) Piston/ Bladder type accumulator complete operation.

2.7.3 Test Report

Shortly after the completion of the field acceptance tests the Contractor shall prepare and forward draft copies of the field acceptance tests report to the employer for review. After review and acceptance, the Contractor shall furnish six (6) copies of final reports.

2.7.4 Design Memorandum

The Contractor shall submit to Employer a design memorandum prepared in accordance to clause 2.5 "Design Memorandum" of General Technical Specification.

2.7.5 Drawings and Documents

The Contractor shall submit all the drawings and documents in accordance with requirements stipulated in clause 2.6 "Drawings & Documents to be supplied by Bidder" of General Technical specification. These drawings and documents shall include at least the following:

i) General arrangement, outline and foundation drawings,

ii) A complete and detailed description of the governor operation explaining various safety, protective and regulation features of digital governor, actuator, cabinet etc. The description shall be written in coherent narrative form, shall be indexed, and shall provide a complete step-by step explanation of the operation of the governor circuits through the sequence- normal start-up, Normal shutdown, emergency shutdown (load rejection) and operation of and recommended setting and programming for all auxiliary circuits, such as brakes, and protective circuits, in the manual and automatic modes,

iii) Functional block diagram of governor control system,

iv) List of tests to be conducted in shop, and at site, during commissioning,

v) Instruments offered, with catalogues/pamphlets,

vi) Governor opening and closing characteristics,

vii) Drawings, showing general arrangement, sections of all major assemblies, sub-assemblies and major components,

viii) Control schematic drawings showing provision of all instruments, devices and functioning of regulating circuits,

ix) Electrical drawings,

x) Erection, Commissioning, operation and maintenance instructions for digital governor system and other accessories etc.

Any additional document not specified above but required to ascertain suitability of design and provisions of this specification shall also be submitted.

2.7.6 Design Calculation

The Contractor shall submit the design calculation in accordance to clause 2.6.4 of GTS covering at least the following, for review/acceptance.

i) Structural analysis of different parts such as pressure accumulator, sump tank etc.

ii) Governor closing and opening time,

iii) Calculation of capacity of oil pressure system,

iv) Calculation of size of oil pressure accumulator,

v) Calculation for capacity of pump, motor and servomotor,

vi) Stability Analysis,

vii) Thickness & velocity calculation/Sizing of oil piping.

The Contractor shall also provide other calculations as required by the Engineer for his approval of the Contractor's design.

2.7.7 Instruction Manuals

The supplier shall prepare manuals covering the information and instructions pertaining to the following sections for guidance during storage, installation and operation & maintenance.

2.7.7.1 Manual for Storage, Preservation and Handling at Site

This manual shall contain detailed information about the system of marking adopted to show sling points, restrictions regarding position of transport of any package & position of

application of any cradle provided for use during transport or site storage/preservation of goods for all items. Four (4) copies of such manual shall be submitted to the purchaser:

2.7.7.2 Manuals for Installation, Testing and Commissioning

This document shall include full and detailed instructions regarding the procedures and precautions to be observed during installation of governor and associated accessories including the use of erection equipment. It shall also include the performance parameters required to be met during installation to demonstrate that the equipment installed is within the tolerance specified in the contract.

The testing and commissioning section shall include full detailed directions for the methods & procedures to be followed, the parameters to be observed & recorded in checking the accuracy of installation and carrying out site tests as required under the contract. It shall also include the performance parameters required to be met for site tests, description of all equipment & instruments provided for these tests and of their use. Four (4) copies of such manual shall be submitted to the purchaser:

2.7.7.3 Manual for Operation & Maintenance

This shall include complete instructions for operation and maintenance of governor and associated equipment not only during the defect liability period but also during its operating life. The directions shall be set out simply, clearly and systematically as per clause 2.11 of General Technical Specification.

2.8 Schedule of Similar Installations

The bidder shall furnish a list of similar type and of similar or higher rating equipment supplied and duly installed & commissioned by him along with the bid. The bidder shall furnish the place and the year of supply and their commissioning dates along with the particulars of equipment supplied.

2.9 Delivery, Installation and Commissioning

The Contractor shall follow the general requirement of Delivery, Installation and commissioning as per relevant clauses in General Technical Specification.

2.10 Schedule of Requirement

Broad schedule of Requirement for Governing system comprises of:-

Sl. No	Description	Unit	Qty.
1	Digital Electro-Hydraulic Governors including oil pressure system, associated piping, SSG, speed switches and other accessories as specified in various clause of this section of specifications.	Nos.	4
2	Instruments, gauges, transducers and temperature detectors for governing system.	Sets	4
3	Spares for governing system as specified.	Set	1
4	Special tools, slings, jigs, fixtures & devices necessary for erection, dismantling and reassembly.	Set	1
5	All piping & fittings within and surrounding the turbine pit associated with governing system	Lot	1
6	Consumables like welding electrodes for site welding and governing oil, grease etc. for initial filling of the system.	Lot	1
7	All power, control & special cables, cable glands, lugs, terminals, connectors etc. required for completion of work	Lot	1
8	All general tools including wrenches, tools and special equipment for assembling and dismantling of governing system.	Set	1
9	Shop assembly & testing of governing system as specified.		
10	Field acceptance test and test equipment and instruments as specified.		

Sl. No	Description	Unit	Qty.
11	Detailed design of all the work, including the furnishing of drawings, reports, computation sheets, calculations, etc. as required.		
12	Installation, maintenance and operation manuals for the major equipment & all accessories.	Nos.	5
13	Online Oil Filtration Unit (Electrostatic Liquid Cleaner)	Nos.	4
14	Low vacuum dehydration & degasification unit (LVDH)	Nos.	4

Any item of supply not explicitly listed but otherwise either implied by the contents of the specification or essential for smooth operation of the equipment shall be construed as forming part of the supply and no additional charges shall be payable for the same.

As and when any particular item/s which was not explicitly listed are found to be essential, the contractor shall affirm the inclusion of the same in the scope of supply without any extra charge.

2.11 Spare Parts

Recommended spare parts shall be supplied in accordance to clause 3.0 "Spare Parts and Tools" of General Technical Specifications. Specified spare parts to be supplied under this Chapter are as follows.

Sl. No.	Description	Unit	Qty.
1	Complete proportional valve assemblies	Nos. of each type	2
2	Directional/Control valves (except solenoid operated)	Nos. of each type	2
3	Solenoid valve	Nos. of each type	2
4	Speed sensing device	Nos.	2
5	Transducer assembly complete of all type used in the system	Set of each type	1
6	Printed circuit card/module	Nos. of each type	2
7	Power supply unit	Nos. of each type	2
8	Pressure oil pump-motor set	No.	1 no.
9	Jockey oil pump-motor set	No.	1 no.
10	Set of micro oil filter of each type used in the electro hydraulic actuator	8 nos. of each type	8
11	Set of oil/ air filters of each type used in oil sump tank	Nos. of each type	2
12	Unloader valve complete assembly	Nos. of each type	2
13	Safety relief valve complete assembly	Nos. of each type	2
14	Coils of solenoid used in the system	Total number required for two (2) units	
15	Indicating lamp bulbs/ LED for each color (Red, yellow, blue, amber etc.)	Nos. of each type	40
16	Sight glass gauges for pressure accumulator and sump tanks	Nos. of each type	2
17	Level switches, level transmitter and level indicator	Nos. of each type	2
18	Pressure switches, pressure transmitter and pressure gauges	Nos. of each type	2
19	Thermometers	Nos. of each type	2
20	Ball and roller bearing used in the pumps and motors	Nos. of each type	2
21	Complete set of gaskets, O-rings, sealing rings and packing	Nos.	2
22	Nitrogen cylinders	Total number required for two (2) units	
23	Valves of each type (25mm and above)	Nos.	2

Besides above, the Contractor shall recommend any additional spare parts, which in his opinion are necessary for satisfactory operation of the system. However, the procurement of these recommended spares shall be at the discretion of the purchaser. The additional recommended spare parts shall be indicated in the Data Sheets of Volume-6.

2.12 Guaranteed & other Technical Particulars

The Contractor shall follow the Guaranteed & Other Technical Particular requirements as specified in Data Sheets of Volume-6.

2.13 Tools and Instruments

The Contractor shall supply all necessary tools and Instruments etc. for installation, repair and maintenance in accordance to clause 3.2 "Tools and Instruments" of General Technical Specification.

2.13.1 Special Tools

The contractor shall supply all the list of such tools including their makes and detailed specification for acceptance by the employer, as recommended by the manufacturer.

The proposed list of special tools must include the following in addition to the tools recommended by manufacturer(s):

i) One set of test cards extension and dummy loads and test loads for the electronic section of the governor,

ii) One set of Pressure Calibration device.

Any special tools that may be necessary or convenient for assembling, dismantling or adjusting the governor equipment, neatly packed in a metal toolbox for convenient storage.

2.13.2 Customary Tools

The Contractor shall supply customary tools and devices. For installation, repair and maintenance as specified below. The details including make of these items shall be as proposed and accepted by the Owner at the time of award of the contract and incorporated in the "Technical data sheets".

Customary tools shall be furnished directly to the Owner in new condition. They shall in no case be used for erection and/or installation purposes during the construction of the plant. They shall serve for operation, maintenance and overhaul work after taking over.

i) One complete set of case hardened wrenches above 24 mm.

ii) Two set of feeler gauges from 0.05 mm to 1 mm in denomination of 0.05 mm, each in sizes of 100, 200, 300 and 500 mm long.

iii) Four (4) no. dial indicators (least count 0.01 mm) with magnetic base.

2.13.3 Tools for Erection and Maintenance

The Contractor shall bring his own tools, devices, testing instrument/equipment's to site in order to erect and install the complete equipment delivered under this section. These shall remain the property of the Contractor unless otherwise agreed to take over any/all of these at mutually agreed conditions.

For on-site assembly, the Contractor shall use the same assembly tools and procedures as those used in the shop.

2.14 Quality Control & Assurance

The Contractor shall submit detailed Quality Assurance Plan and Inspection Schedule for Employer's review and approval in accordance to clause 12.0 of General Technical Specification.

2.15 Deputation of Engineers for witness of Tests, Inspection & Training

The Employer's representatives shall be deputed for the following purposes.

Sl. No.	Description	Batch	No of Days	No. of Engineers and Technicians
1	Training at the plant and design office	2	5	4 Engineers 6 Technicians
2	Shop Inspection and Test	As and when required for inspection and test		

The training of employer's personnel shall be as specified in clause 11.0 "Training of Employer's Personnel" of General Technical Specification.

2.16 Deviations from Specifications

All deviations from these specifications shall be separately listed in the requisite Performa of the bid document, in the absence of which, it will be presumed that the provisions of the specifications are fully complied with by the bidder. However, the deviations, which are better than the specifications shall be considered by the purchaser.

2.17 Completeness of Contract

Any fittings, accessories or apparatus required for successful commissioning though may not have been specifically mentioned in the specification but are usually necessary for the completeness of the works shall be deemed to be included in the specification and shall be supplied by the bidder without any extra cost to the purchaser.

CHAPTER 3: MAIN INLET VALVE AND ACCESSORIES

3.1 Scope of Work

Scope of work under this section covers the provision of labor, tools, plants, materials and performance of work necessary for the design, manufacture, quality assurance, quality control, shop assembly, shop testing, delivery at site, site storage and preservation, insurance, installation, commissioning, performance testing, acceptance testing, training of Employer's personnel, handing over to Employer and guarantee for three years of four (4) sets of Main Inlet Valves, as per the specifications hereunder, each complete with all auxiliaries, accessories, spare parts and warranting a trouble free safe operation of the installation. The Systems shall be suitable for Ambient, Seismic, altitude and other site conditions are detailed in General Technical Specifications.

The scope of work shall be a comprehensive functional system covering all supply and services including but not be limited to following:

3.1.1 Spherical Valve and Associated Components

i) Four (4) sets of 1.7 m diameter turbine Main Inlet Valves of the Spherical type assembly complete in all respect comprising of valve bodies, rotor, trunnions and counter weights, together with bearings, service seal, maintenance seal and appurtenances,

ii) Four (4) sets of embedded and foundation parts,

iii) Four (4) sets of hydraulic operating mechanisms each consisting of two double acting servomotors, including cylinders and necessary mechanical linkages,

iv) Four (4) sets of by-pass assemblies with, piping, hydraulically operated valve, guard valve, isolating gate valve and control equipment,

v) Four (4) sets of combined automatic air vent and air inlet valves on the downstream side of the Spherical Valve,

vi) Four (4) sets of upstream extension pieces with penstock drain arrangement,

vii) Four (4) sets of downstream extension pieces with distributor drain arrangement,

viii) Four (4) sets of oil pumping unit consisting of following main components:

a) All associated valves such as distributing, proportional, control, emergency shutdown, check valves including other types, piping, fittings etc.

b) Dual oil filtration unit with changeover facility along with clogging indication,

c) Oil sump tank,

d) Motor driven main and standby oil pumps mounted on the sump tank,

e) Oil pressure accumulator with associated accessories,

f) Instrumentation such as pressure gauges, pressure switches, pressure transducer, moisture indicator, temperature gauges, temperature switches, level transducer, level gauges, level switch etc. required for the system,

g) Other required accessories.

ix) Four (4) sets control systems including console, electro-hydraulic control, sensing and indicating devices, control piping, and devices for local and remote indication,

x) Four (4) sets of nitrogen based oil pressurization units along with nitrogen bottles,

xi) Four (4) sets of access platforms complete with stairs and guard-rails for access to the manually operated bypass guard valve, isolating valve, locking devices and point of grease lubrication including stairs from MIV/ turbine floor to the top of the valve and floor grating / hatch cover on opening for MIV handling,

xii) Oil for first filling of all components with 10% extra quantity, in non-returnable drums, for all four (4) units,

xiii) One (1) set of hydraulic tensioners complete with power pack, fitting, valves and special handling devices & fixtures for inlet valve components,

xiv) All power cables, control cables and special cables, cable racks, cable glands, lugs, terminals, connectors etc. for cabling between equipment and devices covered in this chapter,

xv) Provision of necessary contacts and/or ports for integration with plant SCADA system,

xvi) Spare parts in accordance to clause 6.11 "Spare Parts" of this section,

xvii) Tools and Tackles in accordance to clause 6.13 "Tools and Instruments" of this section.

Any other item(s) not mentioned specifically but necessary for the satisfactory completion of scope of work defined above, as per accepted standard(s)/best international practices.

3.2 Specific Design and Layout Conditions

3.2.1 Layout and General Arrangement

Each main inlet valve, located at MIV floor, shall be of spherical type complete with separate OPU system located at MIV floor/turbine floor.

The valve shall be used to connect and shut-off penstock during normal unit start-up, shut-down respectively and to permit dewatering of penstocks/pressure shafts. The valves shall also be used to shut-off turbine flows in case of governor failure. The design of the valve shall be such as to resist the hydraulic forces acting directly on the body and rotor under all possible conditions. When fully open, the valve shall provide minimum obstruction to flow of water.

The main inlet valves shall be handled by the powerhouse EOT crane of 200 MT capacities. The contractor shall coordinate with the EOT crane manufacturer for hook approaches and handling by the crane.

3.2.2 Operating Conditions

Depending upon operating requirements, the valve shall be either fully open or fully closed and no partial opening of the valve is envisaged. The normal opening and closing of the main inlet valve shall be by hydraulically operated double acting servomotors and counterweights. Provision shall also be made to close the main inlet valve by counterweight in the worst possible condition.

The valve shall be capable of closing against maximum head, including water hammer for maximum turbine discharge at all operating conditions including runaway with normal working stress on all parts.

3.2.3 Design Considerations

3.2.3.1 Special Design Consideration

The main inlet valve and its operating mechanism, extensions, couplings, bypass valve assembly, piping, sealing and drain system shall withstand safely the maximum stresses from the following operating conditions, with stresses in the materials not exceeding the maximum allowable stress as General Technical Requirements":

i) Valve in open or close position withstanding the total maximum water pressure of 92 bars, which includes the pressure rise allowance,

ii) Opening of the valve at 50% unbalance and closing at 100% unbalance condition.

iii) By-pass valve assembly shall be designed for closure against maximum possible flow rate under maximum gross head and also be designed to open under 100% unbalance condition.

iv) The MIV, in no cases, shall open before disengagement/opening of service seal; Suitable Hydraulic interlock shall be provided.

An over thickness of 1.5 mm shall be considered for all the parts such as valve body, trunnions, rotor/plug and extension pieces in contact with the water, for corrosion and abrasion allowance.

The Contractor shall ensure that the counterweight closing mechanism shall not result in extra dimensioning of the powerhouse.

3.2.3.2 Silt Erosion Consideration and Petrographic Analysis

The project is situated in Himalayan region where the silt content during high flow period is excessive and peaks abnormally during high flood. MIV and associated components may be expected to operate under silt concentration up to 3000 ppm during high flood.

The contractor shall critically study the silt data and chemical analysis of water and take the same into account in designing the main inlet valve and auxiliary equipment susceptible to abrasive effect of silt and making all such specific provisions so as to minimize the effect of silt.

3.3 Standards

The system and equipment shall be designed, built, tested and installed to the latest revisions of the following applicable standards. In the event of other standards being applicable they shall be compared for specific requirement and specifically approved during detailed engineering for the purpose:

Sl. No.	Description	Standard
1	Spherical Valve for Hydropower Stations and Systems	IS 7332

3.4 Rating and Functional Characteristics

Sl. No.	Description	Characteristics
1	Number of valves	4
2	Type	Spherical with split jointed body
3	Nominal diameter	1.7 m
4	Outlet diameter	To suit distributor inlet
5	Penstock diameter	2.35 m
6	Elevation of valve center line	772.50 m
7	Rated head	800 m
8	Rated flow per unit	22.5 m3/sec
9	Design water pressure including water hammer	92 bars

3.5 Design and Construction

3.5.1 Design Stress Limits

The unit stresses under any operating conditions (except for parts subject to pressure testing) shall not exceed one third (1/3) of the elastic limit (yield point) of the material or one fifth (1/5) of the ultimate tensile strength of the material, whichever is less. Further, for parts subject to pressure testing, the unit stresses shall not exceed two third (2/3) of the yield point during pressure testing.

3.5.2 Material Selection and Standards

The material specifications and their standards for major components of Main Inlet Valve shall be as shown below. The material grade and classification wherever specified are obligatory and proposed equivalent national/international standard for the same shall also be considered if their chemical composition, mechanical properties, manufacturing methods are similar/superior and are suitable for proposed use. The Contractor shall establish the equivalence/superiority for acceptance by the Employer.

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Sl. No.	Item	Material	Material Standard
1	Body	Carbon steel	ASTM A537 class 1 or ASTM A216Gr WCC/ ASTM A 516 Gr 60, 70 / IS: 2856 / S355J2+N, EN 10025-2
2	Rotor/Plug	Carbon steel	ASTM A537 class 1 or ASTM A216Gr WCC / ASTM A 516 Gr 60, 70 / IS:2856 / S355J2+N, EN 10025-2
3	Trunnions	Carbon steel	ASTM A216Gr WCC / IS:2856 / S355J2+N, EN 10025-2
4	Connection Sleeve/ extensions	Carbon steel,	ASTM A537 class 1 / ASTM A517 Gr F ASTM A517 Gr F
5	Permanent seat of seal, seal retainers and fasteners	Stainless steel, 13Cr-4Ni	ASTM A240 UNS S41500 / SS 304 / SS415 / X3CrNiMo13-4
6	Service seal	Stainless steel,13Cr-4Ni	ASTM A240 UNS S41500
7	Maintenance seal	Stainless steel, 13Cr-4Ni	ASTM A240 UNS S41500
8	Servomotor Cylinder	Carbon steel	ASTM A537 class 1 or ASTM A216Gr WCC
9	Accumulator	Carbon Steel plate	ASTM A516 Grade 70

3.5.3 Valve Body

3.5.3.1 General

The valve body shall be in two pieces, made of welded plate steel, or of cast steel, or a combination of both, bolted together by hydraulically pre- stressed bolts with preferably vertical split joint. It shall be of rigid construction and adequately ribbed as necessary to minimize distortion under full load and maximum pressure. The trunnion bearing housings shall be integral with the valve body and supported by it. The valve body shall be provided with flanges for bolted connections to similar flanges on the valve body extensions. The valve body and rotor shall be machined only after it has been subjected to stress-relieving heat treatment.

The valve body shall be designed to avoid any abrupt changes in velocity. Water passage may be so shaped so as to give either constant velocity or gradual increase in velocity in the direction of flow. Minimum loss of head shall be kept in view while designing valve body, rotor and extensions.

3.5.3.2 Foundation Parts

The concrete foundation shall be designed and provided by the civil contractor in the first stage concrete. The Contractor shall design the necessary anchoring to be embedded in the concrete structure, for most severe load conditions. The valve body shall be provided with integral supporting feet designed for transmitting the full load, including the weight of the flanged extensions and contained water, servomotor thrust to base plates secured in the concrete pedestals. Provision shall be made in the valve feet for minimum 8-10 mm movement of the valve body assembly along the penstock axis. The necessary base or sole plates complete with anchor bolts shall be furnished.

3.5.3.3 Valve Seals and Seats

The material for service seal & maintenance seal shall be of stainless steel. Other type of proven sealing arrangement/ sealing material in respect of service and maintenance seal can also be accepted subject to Employer`s approval. Both the seals shall be hydraulic operated.

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The sealing surface shall be so designed/ constructed that there is no jamming when water is drained from the generating unit after closure under full head and there is minimum damage on the seat and the seal.

The service seal adjustment feature may be accomplished by seal retaining elements from the downstream side of the valve. It shall be possible to adjust and replace the service seal from downstream side with the inlet valve closed.

Working seal/seats and bypass valve shall be suitably hard coated with HVOF process using tungsten carbide material.

The seal retainers and fasteners shall be of 13Cr-4Ni stainless steel. The seals and the seats shall be designed and constructed of such material that they shall provide maximum tightness, maximum resistance to the silt, minimum maintenance, minimum leakage, convenient adjustment and replacement.

3.5.3.4 Permissible Leakage

i) Maximum permissible leakage from the service seal shall not exceed one (1) lpm /meter periphery of seal.

ii) Maximum permissible leakage from the maintenance seal shall not exceed three (3) lpm/ meter periphery of seal.

3.5.4 Flanged Extensions and Erection Joints

3.5.4.1 General

The valve shall be furnished with two valve body extensions, one for the inlet side of the valve and another for the outlet side. The extensions shall be of plate steel construction, designed for a hydrostatic pressure of 92 bars.

All necessary nuts, bolts and gaskets for the flanged connection between the valve body and the extensions shall be furnished by the Contractor. No special supports shall be provided for the extensions. Their weight, including contained water shall be carried through the flanged joints to the valve body.

3.5.4.2 Upstream Connection

The valve body inlet extension shall be provided with bolting flanges at one end for connection to the valve body. Extra length to accommodate any variations in the distance between penstock and valve flange for connecting the inlet extension to the valve body shall also be included in scope of supply. The connection of the upstream extension piece to the penstock shall be of welded type. The Contractor shall cut, chamfer and weld together the end of the penstock and the valve extension including all necessary NDT or heat treatment.

The contractor shall provide necessary suitable size openings for by-pass valve and penstock drain valve.

The material of the penstock shall be ASTM A537 cl.1.

The inlet pipe shall be fabricated of high strength steel plates with respectively bolted flanged end for connection to the valve (inlet) and welding end for connection to the penstock reducer pipe (size 2.35x1.7m).

The Bidder shall suitably co-ordinate with the penstock supplier to match the dimension of upper stream MIV body with penstock.

3.5.4.3 Downstream Connection (flexible couplings)

An extension pipe with sleeve type coupling (not transmitting any axial load) of an approved type shall be furnished to connect the valve to distributor inlet pipe. The coupling shall allow the valve to be displaced by approximately 15mm along the penstock axis due to hydraulic forces and thermal expansion/ contraction and to facilitate erection and dismantling of the

extension pipe for replacement of the inlet valve seal and to allow for any small differences in distributor extension length. The extension pipe shall be complete with all necessary steel flanges, seals/gaskets, coupling bolts and suitable size openings for by-pass valve, spiral case drain and air release valve.

The surfaces of the coupling in contact with the seal, extension piece and the seal groove shall be plated/ lined with stainless steel overlay of minimum 5 mm thick.

3.5.5 Valve Rotor/Plug and Trunnions

3.5.5.1 Valve Rotor

The valve rotor shall be made of cast steel in one piece, or of welded plate steel construction, or a combination of both, ruggedly designed and heavily ribbed internally to minimize deflection under load in the closed position. The flow passage shall be such that any head losses and flow disturbances can be reduced to a minimum. The rotor shall be machined at its rim.

The surfaces of seat of the seals in contact with the rotor, flange and body shall be plated with stainless steel lining/overlay of minimum 5 mm thick.

3.5.5.2 Trunnions

The trunnions shall be made of forged or cast steel and shall be welded to the valve rotor. The rotor and trunnions shall be designed to sustain maximum differential pressure across the valve in closed condition and emergency condition. The trunnion bearing and seal surfaces shall be provided with replaceable stainless steel sleeves. Appropriate seals shall be provided at the outside ends of the trunnion to prevent leakage. The design and construction of the seals shall be based on a recognized design giving due regard to dependability, long life, and convenient replacement.

3.5.6 Main Bearings

The main bearings shall be of the sleeve type, supported integrally within the valve body. The bearings shall be designed and constructed so that all necessary adjustments may be made from outside the bearing housings. The sleeve bearings shall be of corrosion resisting material and shall be designed so that deflection and trunnion slope caused by the water load on the rotor in the closed position shall not result in binding between the trunnions and sleeves. The bearing shall be built into the valve body and shall transmit the loads to body. The bearings of either side shall be interchangeable. The main bearing shall be designed for its replacement in situ.

3.5.7 By-Pass Assembly

Each main inlet valve shall have one (1) number of by-pass assembly of minimum DN 200 complete with hydraulically operated valve, piping and necessary electrical controls. Each bypass valve shall have hand operated guard valve at upstream side and isolating gate valves at the downstream side along with piping. The opening and closing of the bypass valve shall be controlled by hydraulic pressure from the oil pumping unit.

Sizing of the bypass assembly, guard valve, isolating valve and piping shall take into account to maintain balance condition even if nozzle leakages have increased due to wear & tear, erosion and cavitation. The by-pass assembly shall be properly supported to minimize vibration and noise. The bypass assembly shall be provided with a suitable size diffuser.

Upstream tapping for bypass assembly pipeline shall be done from MIV body.

The by-pass, isolating and guard valves shall be of cast or forged steel with wearing parts of corrosion resisting material. A hand wheel mechanism for manual operation of the bypass valve shall also be provided.

The by-pass line shall be used for filling the turbine distributor and equalizing the pressure across the main inlet valve rotor before opening.

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Non-contact type limit switches of reputed make, each with electrically independent contacts, shall be provided as required to accomplish the specified control and alarm functions.

3.5.7.1 Pressure Gauge and Switches

Necessary pressure gauges, pressure switches, pressure transducer including differential pressure gauges & switches shall be provided for visual measurement and to accomplish the specified controls in the upstream and downstream side of the valve rotor.

3.5.7.2 Piping

The by-pass piping shall be heavy duty seamless/stainless steel grade with flanged connections. The necessary bolts, nuts and gaskets shall be furnished by the Contractor to make the system complete. The pressure rating of valves shall not be less than PN 100.

3.5.8 Valves

3.5.8.1 Air Inlet and Vent Valve

One automatic combined air admission and air release valve complete with a service gate valve and the necessary bolts and gaskets shall be furnished for installation on top of the downstream extension pipe. The size of the valve shall be as required to exhaust the air trapped in the distributor when the by-pass is opened for filling the distributor and to admit air when the main inlet valve is closed and the distributor is being drained. The air and vacuum valve shall be designed to prevent any water spray during its operation.

3.5.8.2 Penstock and Distributor Drainage System

The penstock including pressure shaft (downstream portion of Butterfly Valve) shall be drained by means of turbines with actuated deflector. In order to evacuate the remaining quantity of water in the pressure shaft & penstock, a penstock drainage system shall be installed. One no. heavy duty gate valve of suitable size, made of forged steel, along with one additional guard valve shall be provided. The drain arrangement shall have adequate flexible coupling arrangement to cater the thermal expansion/ contractions of the penstock. The drainage system is expected to be leakage free during operation.

The penstock drain arrangement i.e. inlet of penstock drain valve and distributor drain valve shall be connecting though a boss along with stainless steel grating. The drainpipe shall be seamless carbon steel of minimum schedule 80.

The pressure rating of the valves shall not be less than PN100.

3.5.9 Operating Mechanism

The main inlet valve operating mechanism shall consist of two double acting servomotors with base plate and anchor bolts and connecting linkage for opening and closing by oil pressure. The lever shall be made of steel and shall be keyed to the valve trunnion. The operating mechanism shall have sufficient capacity to move the valve rotor smoothly through one full opening and two closing strokes under conditions specified in Clause “Operating conditions” of this section, with the minimum operating oil pressure.

The operating mechanism shall be of sufficient capacity to close the valve in 45 seconds. The opening time shall be approximately equal to the closing time. The closing and opening times shall be adjustable between 45 and 120 seconds with positive means for locking these adjustments. The minimum permissible closing time shall be controlled by a fixed orifice installed directly at the servomotor outlet as to prevent fast closure of the valve in case of oil piping failure. The main inlet valve shall be opened normally in balanced conditions or with a maximum difference of pressure of 50% between both sides, however, the valve shall be designed to be capable of opening under unbalanced conditions at maximum flow.

The angular travel of the rotor shall not be more than 90 degree from open to shut-off position.

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The operating mechanism shall include suitable positive stops to limit the rotor travel at the fully opened and fully-closed positions. A mechanical position indicating device shall be provided on the operating mechanism to indicate the position of the valve rotor.

Provision shall be made to manually lock the main inlet valve in closed position. Lock shall be capable of holding the main inlet valve in the closed position against full combined force of both the servomotors. Parts with sliding contact shall have self-lubricating bushing and corrosion resistant shafts with surfaces finish and coating as required.

All pilot and control valves, limit switches and interlocks necessary to coordinate the operation of the lock with the main valve and bypass valve sequence of operation shall be provided. When the valve is locked in the closed position, the electric circuits for opening the valve shall be inoperative. Provision shall also be made for padlocking the locking device when in the closed position.

The supply shall include the hydraulic control system complete with the necessary valves, piping, fitting and filters etc. for the operation.

3.5.9.1 Servomotor

The servomotor cylinder body shall be accurately bored to receive the piston. The servomotor shall be provided with suitable gaskets or seal rings designed to remain oil tight at maximum operating pressure.

The operating cylinders shall be sized to open and close the valve with minimum system oil pressure and to retard closing under the most adverse combination of counterweight force and hydraulic torque on the valve rotor due to emergency closure at maximum turbine discharge without exceeding the cylinder design pressure.

The piston rod connecting the piston to the operating linkage shall be hardened, corrosion resistant steel and shall be provided with hard chromium layer. The pistons shall be provided with approved type packing and metal piston rings suitable for the required oil pressure service.

There shall be positive margin in the cylinder with respect to full stoke length or any other alternate arrangement either in piston or cylinder for avoiding seizing of Servomotor when fully opened for longer period.

3.5.9.2 Counter Weight

The counterweights shall be sized to provide net closing torque on the valve rotor under all possible operating conditions. Counterweight shall be suitable size plates with smooth finish.

3.5.10 Oil Pressure System

3.5.10.1 General

Each unit shall have an independent oil pressure system for operation of the main inlet valve for the operating mechanism, servomotor and controls. The oil pressure system shall consist of a sump tank, two (2) AC motor driven screw pumps of suitable capacity, pipes, fittings etc.

The design shall be compact, and there shall be easy access to all the components for maintenance and replacement. All the components shall be selected to assure high reliability, long life, low noise and minimum heating of the oil.

3.5.10.2 Operating Pressure

The normal operating pressure of the oil pressure system shall be approximately 100-120 bars and medium shall be nitrogen/oil.

3.5.10.3 Oil Pumps

Mounted on the oil sump tank, two oil pumps shall be provided, one acting as “main” and the other as “standby”. Each oil pump for the oil pressure supply system shall be independently driven by a 3-phase 415V AC electric motor and each shall have a capacity sufficient to operate

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the complete main inlet valve oil pressure system. A complete pump logic control system shall be provided that shall permit the selection of either pump, as the main unit with the other pump acting as a standby, which shall cut in automatically to supply the oil and close a set of alarm contacts.

Each pump shall have following devices/ provisions:

i) One electrically controlled loading / unloading valve at the outlet, so that it discharges to the sump at reduced pressure or accumulator. It shall be possible to run one main pump continuously without overheating the oil.

ii) At the outlet, one safety valve which shall be adjusted to open at more than the maximum operating pressure as per manufacturer recommendation and shall be sized to pass the pump full flow with pressure increase less than 10 %.

iii) Hand operated valves at the outlet of the pump, to permit isolating of pumps from the oil pressure.

iv) A suitable oil strainer in the suction line,

Each main and standby oil pump shall be of the screw type, with a capacity (l/ minute) of not less than 1.5 times of the total active oil volume of both the servomotors per minute or higher when operating under the pumping pressure recommended by the Contractor. Each pump shall be self-priming under maximum oil pressure.

Each pump shall be direct-connected to a 415 V, 3 phase, 50 Hz, squirrel- cage, low starting current, induction type motor designed for full voltage across the line starting and conforming to IEC standards, with class F insulation. The motor shall have windings with moisture and oil-resistant insulation. The windings shall be braced for line start application. The capacity and torque shall be suitable for the pump requirements.

The pumps operation shall be as follows:

i) No load starting by returning the oil flow through a unloading valve

ii) In case of pressure drop, the main pump shall start and keep the pressure within the operating limits by closing and opening the unloading valve i.e. restore the pressure and then stops

iii) In case of excessive pressure drop the standby pump shall start, both main and standby pump running together shall restore the pressure and then stop.

iv) In case of failure of main pump, the standby pump shall automatically be considered as main.

v) Automatic changeover from main to standby on the basis of set time running hours.

All valves and mechanisms shall be accurately set and tested in the shop before delivery.

Combination heavy-duty magnetic starting contactors with fused disconnecting switches and three thermal overload devices shall be furnished and shall be mounted on or adjacent to the pump units.

A 415/240 V control circuit transformer shall be provided within each magnetic starter enclosure, of suitable size for control of the starter and supply to the starter accessories. Suitable terminal blocks with marking strips shall be provided in accessible places for the control wiring. All control equipment shall be suitable for operation from the 220 V control circuit transformer. The control equipment shall include a timer, adjustable from 0 to 60 seconds which shall prevent simultaneous closing of the magnetic starters when the power supply is removed and then restored.

A manual control switch shall be provided to select one of the two pumps as the lead pump. An alarm shall be provided to indicate continuous running of the lag pump over on adjustable period of time.

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The un-loader valves shall be operated from the pressure accumulator pressure by pilot lines, complete with isolating valves and filters or by pressure switches and shall be equipped with "snap" action pilot valves. Hand-operated valves shall be provided to permit isolating pumps from the oil pressure. Adjustable temperature switches with two (2) electrically separate contacts suitable for operation at 220 V DC located in the sump tank for oil high temperature alarm shall be provided.

The connections to all pumps shall be arranged so that any pump may be removed for repair or replacement without interfering with the continuous operation of the system.

3.5.10.4 Oil Sump Tank

The inlet valve system shall be supplied with a sump tank of sufficient capacity to hold at least 10 percent more than the total quantity of oil in the entire inlet valve system including oil pressure accumulator. The sump tank shall be designed and have connections for venting and overflow.

The sump tank shall be provided with a manhole of 500 mm diameter with a suitable oil resistant gasket for access to the interior of the tank. A suitable oil level glass shall be provided to indicate the level of the oil in the tank, marked with low and high level marks, complete with both hand shut-off valves and automatic means of shutting off oil discharge in the event of breakage.

Suitable connections for filling and draining the tank, and connections for an oil purifier shall be provided. The oil purifier connections shall consist of two pipe outlets and valves, one located near the bottom on one side and the other near the top on the opposite side. A vertical filter screen shall be arranged to divide the sump tank into "clean" and "dirty" oil compartments. All strainers shall be readily removable for cleaning. The outlets of all oil pipes to the sump shall be below low oil level. Any component that requires adjustments shall not be located inside the sump tank. Low and high level switches shall be provided for sump tank, suitable for 220 V DC, which operate alarms whenever the oil level reaches the present level. An oil temperature switch wired to cut off power supply to the oil pumps in the event of high temperature shall also be provided. Moisture indicating device shall also be provided for moisture indication.

i) Proportional valve oil filtering

Suitable dual on line oil filter with changeover and clogging indication shall be provided in main inlet valve actuator supply circuit to ensure that impurities as recommended by the manufacturer are avoided. Clogging indicators with electrical contacts to indicate the clogging of filters shall be provided. Filter elements used shall be cleanable with Petrol.

ii) Main circuit oil filtering

One oil filter shall be provided in the pumps unloading discharge line to ensure the main circuit impurities as recommended by the manufacturer are avoided. Clogging Visual indication with electrical contacts to indicate the clogging of filter shall be provided. Filter elements used shall be cleanable with Petrol and easily changeable. Main circuit oil filter shall be equipped with one automatic by-pass allowing operation in case of clogging of the filter element.

The filter system shall be able to handle the discharge flow of both main and standby Pumps.

iii) Cooling system

If required, one heat exchanger shall be provided to maintain the oil temperature within 50°C. The heat exchanger shall be installed on the unloading return line to the tank and shall be sized for continuous operation of the main pump maintaining pressure between

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operating limits and no create water temperature increase more than 4°C. Temperature indicators on both sides of coolers shall be provided.

3.5.11 Oil Pressure Accumulator

3.5.11.1 Capacity

The pressure accumulator shall have a total volume of at least twenty five (25) times the combined active volume of the two servomotor cylinders of the main inlet valve and shall be designed for a pressure ten (10) percent above the actual maximum system pressure. The size of the accumulator shall be such that it shall be possible to operate the main inlet valve three (3) times (2 "C"+1 "O") from minimum normal oil pressure without the operation of main inlet valve oil pumps and without dry nitrogen admission. At the remaining pressure the inlet valve mechanism should still operate with a safe margin.

3.5.11.2 Construction and Safety Features

The accumulator shall be constructed from plate steel conforming to ASTM A 516 grade 70 or higher in accordance with part UW of the ASME Code for Unfired Pressure Vessels, Section VIII, for the maximum working pressure of the system.

An adequate sized manhole of 600 mm diameter, with a suitable oil- resistant gasket of 6 mm Neo-Lancet or equal shall be provided on the pressure accumulator.

The accumulator shall be painted on the inside and on the outside as per approved painting system. Thickness of inside painting shall be such that these do not flake off during operation. Prior to shipping, all threaded openings shall be closed with standard pipe plugs. Flanged openings shall be protected with blind flanges with gaskets bolted in position.

All connections to the pressure accumulator, with the exception of the nitrogen supply and the upper gauge connections etc. shall be made below the low oil level and shall be designed to prevent foaming. Bypass valves shall be provided to drain the pressure accumulator into the sump for cleaning or repairs.

The accumulator shall be equipped with a pressure gauge, a safety relief valve, pressure transducer, burst rotor and at least two (2) oil-level sight gauges metallic magnetic float pipe type with indication, switches and transmitter. The safety relief valve shall be set to open at 110 percent of the maximum operating pressure of accumulator. The sight gauges shall be long enough to overlap the high and low oil levels by at least 50 mm. The safety relief valve should release nitrogen to atmosphere in a manner not injurious to personnel or equipment in the vicinity of the accumulator.

The accumulator shall be provided with a float/isolating valve assembly to prevent nitrogen admission into the inlet valve oil piping system under conditions of low oil level.

The accumulator shall be provided with an automatic nitrogen admission system to maintain a proper proportion of the nitrogen cushion volume. Manufacturer shall supply all necessary piping, fittings, solenoid-controlled valves, pressure and level switches required for this system. The solenoid shall be suitable for operation at 220 V DC and completely wired.

Pressure switches shall be of approved make. In addition to echelon control, the following provisions shall be made for each pressure accumulator:

i) Normal pressure signal for unit start interlock,

ii) Inlet valve oil low pressure alarm to the station annunciator,

iii) Extreme low-pressure trip and unit shutdown interlock,

iv) Automatic nitrogen admission.

All Instruments necessary for proper and safe operation of the unit shall be supplied with at least:

i) One oil pressure transmitter,

ii) One oil level transmitter with switch for normal oil level unit start interlock,

iii) Low level switch – alarm,

iv) Low level switch – unit trip,

v) Very low level switch – Unit trip and close isolating/ float valve.

All transmitters shall be 4 to 20 mA type. Contractor is free to use individual suitable pressure and level switches. In this case, all contacts shall be adjustable electrically separate and suitable for 220 V DC operation.

The pipe connections for all pressure and level switches shall be independent of the oil supply lines to the servomotors and shall be provided with individual shut off valves and bleed valves as necessary.

In addition to above, one pressure transducer for nitrogen gas shall be installed for monitoring the nitrogen gas pressure through plant SCADA System.

3.5.12 Miscellaneous Components

3.5.12.1 Lifting and Handling Fixtures

The Contractor shall provide lifting fixtures and special tackles and devices for handling of major components of main inlet valve like valve body, rotor, transition sections, servomotors, counterweight, bearings etc. These devices shall include at least the following:

i) One (1) valve handling and lifting device for handling and lifting the assembly of valve in-situ,

ii) One (1) valve rotor lifting device and set of special nylon slings for lifting and handling the valve rotor, servomotors, levers, counterweight etc.

3.5.12.2 Nameplate

A rating nameplate of stainless steel material shall be attached to each major item of equipment supplied. This plate shall be permanently engraved with the designed full load ratings, serial number, type number, date of manufacture and other identification deemed necessary. Hydraulic and electric control system diagram plates shall also be supplied. The material and the identifying inscription shall be approved by the Employer.

3.5.12.3 Access Platforms, Hatch Cover, Floor Grating and Stairs

Walkway, platform, staircases, handrails etc. shall be provided for convenient and safe access to all operating equipment and points of lubrication. Also chequered plate/ grating covers shall be provided for MIV removal hatch, equipment handling hatches and opening/trenches for cable, cable trays, pipes, ducts or any other trench/ opening required for completing the floors around and over the works supplied under the contract.

The material for all handrails shall be stainless steel. Gratings for hatches, platform, walkways, staircases etc. shall be galvanized and be factory made; fabricated mild steel electro forged conforming to relevant standard as specified in GTS.

3.5.13 Oil and Water Piping

All Oil piping shall be seamless stainless heavy duty steel and shall include all piping to the oil pressure supply system consisting of sump tank, pressure accumulator, servomotor, cabinet instrumentation etc. as required. The piping shall be of such size that the maximum oil velocity shall not exceed 3.0 m/sec in the pressure lines and 1.5 m/sec in the return lines. Minimum pressure anywhere in the oil piping system during maximum speed of valve operation shall not be less than 0.5 bar absolute.

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The entire piping system shall be welded, in so far as practicable, leaving only such flanged connections as may be necessary for erection or possible subsequent dismantling for repair.

The piping shall be thoroughly pickled, cleaned, and the interior coated with oil before shipment. Prior to shipment, blind flange with gaskets on the flanged connections, screwed caps on the threaded ends and suitable plugs in plain ends shall be provided to prevent the entrance of foreign matter into the piping during shipment or while awaiting installation.

Water piping shall be made of heavy duty seamless steel pipe in accordance to General Technical Specification (GTS)" and shall have flanged connections as may be necessary for erection or possible subsequent dismantling for repair.

3.5.14 Control and Monitoring

The main inlet valve and associated accessories/equipment shall be controlled and monitored at three levels:

i) By respective local control cubicles,

ii) By respective Unit Control Boards,

iii) By Computerized control and monitoring (SCADA) system through Unit Control Boards.

The Contractor shall make provision of contacts and/or ports in local control cubicles for interfacing with SCADA system for control and monitoring.

The normal control by the SCADA system shall be through Unit Control Boards. It shall be the responsibility of the Contractor to make all necessary provisions required to achieve seamless and compatible interfacing of the system with SCADA system.

Local control shall be performed in an independent and standalone manner, and all information (faults, alarms, measurements, status) necessary for such control shall be displayed locally.

If the system consists of redundant sub systems, the priority of operation of such sub systems shall be selectable either from SCADA system or locally.

3.5.14.1 Instrumentation

Indicating instruments as required shall be installed on local control panel and indications may be replicated in Local Control Board/ control room for common services.

The main inlet valve control system shall be provided with at least the following to accomplish the specified alarm, indications and interlocking function:

i) Pressure gauges, pressure transducers and switches for measurement and detection of the pressure in the turbine distributor and upstream transition section,

ii) Differential pressure switch and gauge for upstream and downstream sides of Main Inlet Valve pressure,

iii) Suitable nos. of pressure and level switches/ transmitter for auto operation of the pumps, nitrogen admission start-stop and annunciation purposes in the accumulator,

iv) Auto selection of OPU pumps on account of running time and mechanical & electrical fault,

v) Temperature and moisture detector for MIV OPU,

vi) Pressure measurement for MIV Opening and Closing oil line respectively,

vii) Level switches and level indicator for sump tank and accumulator,

viii) Linear displacement transducer (LDT) for position and velocity measurement of the accumulator piston,

ix) Non-contact type position switches for fully open, partly open, partly closed and full closed valve position for main inlet valve,

x) Non-contact type position switches for fully open and fully closed, position of by-pass valve,

xi) Electromagnetic flow meter or suitable type on the by-pass circuit (if applicable).

xii) Manual locking devices in closed and open position of MIV.

xiii) Non-contact type position switches for indication/ interlocking purposes for the valve manual locking mechanism,

xiv) Non-contact type position switches for detection of engaged- released and position of valve maintenance seal and service seal.

xv) Pressure measurement to detect abnormal pressure decrease in servomotors supply circuit.

xvi) Limit switches in the isolation valve of the oil pressure tank to detect isolated valve opening and closing respectively.

Any other instrumentation required during detailed engineering shall be provided.

3.6 Performance Criteria and Guarantees

3.6.1 Performance Guarantee

The main inlet valve along with all auxiliaries and accessories shall be capable of performing intended duties under specified conditions. The Contractor shall guarantee the reliability and performance of the individual equipment as well as of the complete system as detailed in the specifications and Data Sheets of Volume-6. The Main inlet Valve along with upstream extension piece and downstream extension piece shall be shop tested at 1.5 times the design pressure.

3.7 Inspection & Tests

3.7.1 Shop Assembly and Tests

3.7.1.1 Shop Tests

The completely assembled valve and by-pass valve with operating mechanism and control mechanism shall be tested at manufacturer' works, subjected to operating test, pressure test and leakage test.

3.7.1.2 Operating Test

The completely assembled valve shall be operated for several opening and closing cycles to demonstrate satisfactory operation.

3.7.1.3 Pressure Test

With both ends of the valve extensions closed by means of test heads and with the rotor in slightly open position, the valve body and by-pass system shall be subjected to a hydrostatic test pressure of 1.5 times the design pressure, to determine the soundness of the valve body whether there are any leaks. The pressure in the valve body shall be maintained for at least 30 minutes. Upon completion of the leakage test the downstream cover removed, to determine the soundness of the rotor.

3.7.1.4 Leakage Test

Leakage test shall be performed on the upstream and downstream (separate test for each) valve seals under the hydrostatic test pressure for not less than 30 minutes. The leakage at this pressure shall be measured.

All necessary materials and labor for performing all the above tests shall be provided by the Contractor.

The test at manufacturer's works shall also be witnessed by a representative of the Owner.

3.7.2 Field Testing

Following field tests shall be performed to ensure that the valve meets specification provisions and manufacturer's guarantee:

i) Pressure test of all installed piping for oil at 1.5 times of the maximum design pressure,

ii) Leakage test of all field piping with pressurized air and soap solution,

iii) Nitrogen leakage test,

iv) Opening and closing of by-pass valve,

v) Opening and closing of main shut-off valve under balance pressure conditions,

vi) Closing of main shut-off valve at rated flow,

vii) Operation of all controls including the mechanical locking devices,

viii) Other tests as deemed necessary by the Owner,

The field-testing shall be witnessed by a representative of the Owner.

3.7.3 Test Reports

Shortly after completion of the field acceptance tests the Contractor shall prepare and forward draft copies of the field acceptance test report to the Employer for review. After review and acceptance, the contractor shall furnish six (6) copies of the final report.

3.8 Drawings, Documents and Design Calculations

3.8.1 Design Memorandum

The Contractor shall submit to Employer a design memorandum prepared in accordance to clause 2.5 "Design Memorandum", of General Technical Specification.

3.8.2 Drawings and Documents

The Contractor shall submit all the drawings and documents in accordance with requirements stipulated in clause 2.6 "Drawings & Documents to be supplied by Bidder" of General Technical Specification.

3.8.3 Design Calculation

The Contractor shall submit the design calculation in accordance to clause 2.6.4 "Design Calculations" of General Technical Specifications of Volume-4 covering at least the following, for review/acceptance.

i) Structural and stress analysis of different parts of main inlet valve components in all loading conditions,

ii) Calculation of hydraulic forces and torque on the valve rotor, trunnion and body during opening and closing of the valve for different positions of the valve and different turbine flow conditions,

iii) Calculations of sizing of bypass valve,

iv) Calculations of foundation loads,

v) Oil pressure system pump-motor capacity calculation,

vi) Calculation of sizing of inlet valve servomotor,

vii) Size and plate thickness calculation for accumulator,

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viii) Sump tank sizing calculation,

The Contractor shall also provide other calculations as required by the Employer for his approval of the Contractor's design.

3.9 Delivery, Installation and Commissioning

The Contractor shall follow the general requirement of Delivery, Installation and commissioning as per relevant clauses in General Technical Specification.

3.10 Schedule of Requirement

Broad Schedule of requirements are given in clause 6.1.1 of this section.

3.11 Spare Parts

Recommended spare parts shall be supplied in accordance to clause. 3 "Spare Parts and Tools" of General Technical Specifications. Mandatory spare parts to be supplied under this Chapter are as follows.

Sl. No	Description	Unit	Qty
1	Pressure oil pump motor set	No.	1
2	Ball and roller bearing used in pump and motor	Nos. of each type	2
3	Unloader valve complete assembly	Nos. of each type	2
4	Safety relief valve complete assembly	Nos. of each type	2
5	Set of Oil filters of each type used in the electro hydraulic actuator and pumping set (except pump suction filter)	Nos. of each type	4
6	Level switch, level gauge and level transmitter	Nos. of each type	2
7	Sight gauge assembly for accumulator and sump tank	Nos. of each type	2
8	Pressure switch	Nos. of each type	2
9	Thermometer	Nos. of each type	2
10	Non-contact type position switches	Nos. of each type	2
11	Pressure gauge	Type	2
12	Servomotor complete	No.	1
13	Main inlet valve seal set each consisting of service seal and maintenance seal including fasteners and seal retainers	Sets	2
14	Hydraulic bypass valve	No.	1
15	Guard valve of by-pass valve	Nos.	1
16	Set of bushes for main Trunnions	Nos.	2
17	Main inlet valve body drain valve	No.	1
18	Solenoid valve	Nos. of each type	2
19	Solenoid Coils	Total numbers required for two (2) Units	
20	Air vent cum admit valve	Nos.	2
21	Oil pump suction strainer/ filter set	Nos.	2
22	Air filter set	Nos. of each type	2
23	Nitrogen cylinders	Total nos. required for one unit	
24	Complete proportional valve assemblies	Nos. of each type	2
25	Control valves	Nos. of each type	2
26	Transducers assemblies complete of all type used in the system	Nos.	2
27	Valves of each type (25mmm and above)	Each.	2

Besides above, the Contractor shall recommend any additional spare parts, which in his opinion are necessary for satisfactory operation of the system. However, the procurement of these

recommended spares shall be at the discretion of the purchaser. The additional recommended spare parts shall be indicated in the Data Sheets of Volume-6.

3.12 Guaranteed & Other Technical Particulars

The Contractor shall follow the Guaranteed & Other Technical Particular requirements specified separately in Data Sheets of Volume-6.

3.13 Tools and Instruments

The Contractor shall supply all necessary tools and Instruments etc. for installation, repair and maintenance in accordance to clause. 3.2 "Tools and Instrument" of General Technical Specification.

3.13.1 Special Tools

The Contractor shall list and supply all special tools. List of such tools including their make and detailed specification, shall be submitted for acceptance by the Employer besides the following special tools:

i) Two (2) sets of special tools for maintenance and service seal replacement,

ii) Two (2) sets nitrogen leak detector.

3.14 Quality Control and Assurance

The Contractor shall submit detailed Quality Assurance Plan and Inspection Schedule for Employer's review and approval in accordance to clause 12 of General Technical Specification.

3.15 Deputation of Engineers for Witness of Tests and Inspection

The Employer's representatives shall be deputed for the following purposes.

Sl. No.	Inspection/Test	Qty
1	Shop Inspection and Test	Employer's representatives from time to time

The training of employer's personnel shall be as specified in clause 11.0 "Training of Employer's Personnel" of General Technical Specification.

3.16 Deviations from Specifications

All deviations from these specifications shall be separately listed in the requisite Performa of the bid document, in the absence of which, it will be presumed that the provisions of the specifications are fully complied with by the bidder. However, the deviations, which are better than the specifications shall be considered by the purchaser.

3.17 Completeness of Contract

Any fittings, accessories or apparatus required for successful commissioning though may not have been specifically mentioned in the specification but are usually necessary for the completeness of the works shall be deemed to be included in the specification and shall be supplied by the bidder without any extra cost to the purchaser.

3.18 Employer's Specification

Sl. No.	Item	Unit	Description
1	Manufacturer		By Bidder
2	Applicable standards		IS 7332
3	Nominal Diameter of Main Inlet valve	m	1.7 m diameter (4 Nos) valve for 150 MW unit. In case the turbine manufacturer requires higher size, Bidder may consider accordingly.
4	Direction of flow		Bi – Directional
5	Maximum flow		To suit the maximum flow through the turbine
6	Minimum flow		To suit the minimum flow through the turbine
7	Normal operating pressure		Head conditions suiting the operation of Turbine
9	Maximum Static Head	mwc	800
10	Upstream extension piece		Required
11	Downstream dismantling joint		Required
12	Downstream transition piece		As required by the bidder
13	Material standard		
13.1	Valve body		Carbon Steel to ASTM A 216 Gr WCC/ ASTM A 516 Gr 60, 70 / IS: 2856 / S355J2+N, EN 10025-2 / IS 1030 340 570W
13.2	Valve disc Rotor / Closing Disc		Carbon Steel to ASTM A 216 Gr WCC/ ASTM A 516 Gr 60, 70 / IS:2856 / S355J2+N, EN 10025-2 / IS 1030 340 570W
13.3	Shaft		Stainless Steel ASTM A 276 Gr 431 / P420QH1, EN 10222-4 / ASTM A668 Cl E
13.4	Service Seal		Stainless steel / X3CrNi13-4
13.5	Maintenance Seal		Stainless steel
13.6	Body Seat ring		SS 304 / SS415 / X3CrNiMo13-4
13.7	Seal retaining ring		SS 304 / Equivalent
13.8	Bearings		Bronze/Teflon Coated DU bushes/ PTFE bushes with bronze backing
13.9	Fasteners		
i)	Internal fasteners		SS A4 – 70 / X20Cr13
ii)	External fasteners		HTS / EN 10250 30 CrNiMO8
iii)	Companion flange		Carbon steel with Cadmium plating / Suitable corrosion protection
13.10	Upstream extension piece		ASTM A517 Gr F / EN 10025 S355

FILE NAME:

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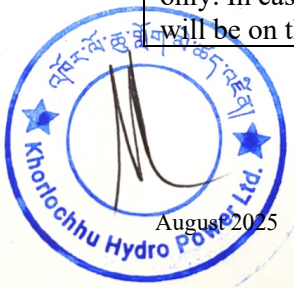

CHAPTER 4: BUTTERFLY VALVE AND ACCESSORIES

4.1 Scope of Work

Scope of work under this chapter covers the provision of labor, tools, plants, materials and performance of work necessary for the design, manufacture, quality assurance, quality control, shop assembly, shop testing, delivery at site, site storage and preservation, insurance, installation, commissioning, performance testing, acceptance testing, training of Employer's personnel, handing over to KHPL and guarantee for three years of Butterfly Valves, as per the specifications hereunder, each complete with all auxiliaries, accessories, spare parts and warranting a trouble free safe operation of the installation. The Systems shall be suitable for Ambient, Seismic, Altitude and other site conditions as detailed in General Technical Specifications.

The scope of work shall be a comprehensive functional system covering all supply and services including but not be limited to following:

4.1.1 Butterfly Valve and Associated Components

i) Two (2) sets of 3.3m diameter Butterfly Valve assembly complete in all respect comprising of valve bodies, rotor/plug, trunnions and counterweights, together with bearings, service seal, maintenance seal and appurtenances,

ii) Two (2) sets of embedded and foundation parts,

iii) Two (2) sets of hydraulic operating mechanisms each consisting of two double acting servomotors, including cylinders and necessary mechanical linkages,

iv) Two (2) sets of by-pass assemblies with, piping, hydraulically operated valve, guard valve, isolating gate valve and control equipment,

v) Two (2) sets of combined automatic air vent and air inlet valves on the downstream side of the butterfly valve,

vi) Two (2) sets of upstream extension pieces with pressure shaft drain valve,

vii) Two (2) sets of downstream extension pieces,

viii) Two (2) sets of oil pumping unit consisting of following main components:

- a) All associated valves such as distributing, proportional, control, emergency shutdown, check valves including other types, piping, fittings etc.
- b) Portable oil filtration unit.
- c) Oil sump tank,
- d) Motor driven main and standby oil pumps mounted on the sump tank,
- e) Oil pressure accumulator with associated accessories,
- f) Instrumentation such as pressure gauges, pressure switches, pressure transducer, moisture indicator, temperature gauges, temperature switches, level transducer, level gauges, level switch etc. required for the system,
- g) Other required accessories,

ix) Two (2) sets control systems including console, electro-hydraulic control, sensing and indicating devices, control piping, and devices for local and remote indication,

x) Two (2) sets of nitrogen-based oil pressurization units along with nitrogen bottles,

xi) Two (2) sets of access platforms complete with stairs and guard-rails for access to the manually operated bypass guard valves, isolating valve, locking devices and point of grease lubrication including stairs to the top of the valve for valve handling,

xii) Oil for first filling of all components with 10% extra quantity, in non-returnable drums, for both the butterfly valve units,

xiii) One (1) set of hydraulic tensioners complete with power pack, fitting, valves and special handling devices & fixtures for butterfly valve components,

xiv) All power cables, control cables and special cables, cable racks, cable glands, lugs, terminals, connectors etc. for cabling between equipment and devices covered in this chapter,

xv) Provision of necessary contacts and/or ports for integration with plant SCADA system,

xvi) Spare parts in accordance to clause 8.11 "Spare Parts" of this chapter,

xvii) Tools and Tackles in accordance to clause 8.13 "Tools and Instruments" of this chapter.

Any other item(s) not mentioned specifically but necessary for the satisfactory completion of scope of work defined above, as per accepted standard(s) / best international practices.

4.2 Specific Design and Layout Conditions

4.2.1 Layout and General Arrangement

Each Butterfly valve, located in Valve house cavern, shall be complete with separate OPU system located in valve house cavern. The OPU system shall be nitrogen and oil pressure operated.

The valve shall be used to connect the pressure shaft in normal operation and to shut-off water in case of MIV failure and also to permit the dewatering of Pressure shaft through Penstock drain Valve/MIV/Units. The design of the valve shall be such as to resist the hydraulic forces acting directly on the body and disc under all possible conditions. When fully open, the valve shall provide minimum obstruction to flow of water.

The Butterfly valves shall be handled by the Valve house EOT crane of 60/15T capacities. The contractor shall coordinate with the EOT crane manufacturer for hook approaches and handling by the crane.

4.2.2 Operating Conditions

Depending upon operating requirements, the valve shall be either fully open or fully closed and no partial opening of the valve is envisaged. The normal opening and closing of the Butterfly valve shall be by hydraulically operated double acting servomotors and counterweights. Provision shall also be made to close the valve by hydraulic oil pressure in the worst possible condition. The Valve shall have provision of maintenance seal to undertake repair/removal of service seal without dewatering the upstream section i.e. upstream horizontal limb of Pressure shaft.

The valve shall be capable of closing against maximum head, including water hammer for maximum turbine discharge at all operating conditions including runaway with normal working stress on all parts.

4.2.3 Design Considerations

4.2.3.1 Special Design Consideration

The Butterfly valve and its operating mechanism, extensions, couplings, bypass valve assembly, piping, sealing and drain system shall withstand safely the maximum stresses from the following operating conditions, with stresses in the materials not exceeding the maximum allowable stress as per General Technical Specifications:

i) Valve in open or close position withstanding the total maximum water pressure of 10.5 bars, which includes the pressure rise allowance,

ii) Opening of the valve at 50% unbalance and closing at 100% unbalance condition,

iii) By-pass valve assembly shall be designed for closure against maximum possible flow rate under maximum gross head. And also, be designed to open under 100% unbalance condition.

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An over thickness of 1.5 mm shall be considered for all the parts such as valve body, trunnions, disc and extension pieces in contact with the water, for corrosion and abrasion allowance.

The Contractor shall ensure that the counterweight closing mechanism shall not result in extra dimensioning of the BFV house cavern.

4.2.3.2 Silt Erosion Consideration and Petrographic Analysis

The project is situated in Himalayan region where the silt content during high flow period is excessive and peaks abnormally during high flood. Butterfly valve and associated components may be expected to operate under silt concentration up to 3000 ppm during high flood. The petrographic analysis of silt in water and chemical analysis of water is detailed in GTS.

The contractor shall critically study the silt data and chemical analysis of water and take the same into account in designing the Butterfly valve and auxiliary equipment susceptible to abrasive effect of silt and making all such specific provisions so as to minimize the effect of silt.

4.3 Standards

The system and equipment shall be designed, built, tested and installed to the latest revisions of the following applicable standards. In the event of other standards being applicable they will be compared for specific requirement and specifically approved during detailed engineering for the purpose:

Sl. No	Standard	Description
1	IS 7326	Penstock and turbine inlet butterfly valves for hydropower stations and system

4.4 Rating and Functional Characteristics

Sl. No.	Items	Characteristics
1	Number of valves	2
2	Type	Butterfly double seal lattice disc
3	Nominal diameter	3.3 m
4	Pressure shaft diameter	3.3 m
5	Elevation of valve center line	1548.50 m
6	Maximum static head	100 m
7	Rated flow per valve	44.5 m3/sec

4.5 Design and Construction

4.5.1 Design Stress Limits

Design stress limits shall be as per clause 4.2.1.2 “Maximum allowable stresses” of General Technical Specifications.

4.5.2 Material Selection and Standards

The material specifications and their standards for major components of Butterfly valve shall be as shown below. The material grade and classification wherever specified are obligatory and proposed equivalent national/international standard for the same shall only be considered if their chemical composition, mechanical properties, manufacturing methods are similar/superior and are suitable for proposed use. The Contractor shall establish the equivalence/superiority for acceptance by the Employer.

S. No	Item	Material	Material Standard
1	Body	Carbon steel	ASTM A 216 Gr WCC/ ASTM A 516 Gr 60, 70 / IS: 2856 / S355J2+N, EN 10025-2
2	Disc	Carbon steel	ASTM A 216 Gr WCC/ ASTM A 516 Gr 60, 70 /

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			IS: 2856 / S355J2+N, EN 10025-2
3	Trunnions	Carbon steel	ASTM A216Gr WCC
4	Connection Sleeve/ extensions	Carbon steel	ASTM A537 class 1
5	Permanent seat of seal, seal retainers and fasteners	Stainless steel, 13Cr-4Ni	ASTM A240 UNS S41500
6	Service seal	Rubber of solid section	As Applicable
7	Pressure Accumulator	Carbon Steel Plate	ASTM A516 Grade 70

4.5.3 Valve Body

4.5.3.1 General

The valve body shall be in two pieces, made of welded plate steel, or of cast steel, or a combination of both, bolted together by hydraulically pre- stressed bolts with preferably vertical split joint. It shall be of rigid construction and adequately ribbed as necessary to minimize distortion under full load and maximum pressure. The trunnion bearing housings shall be integral with the valve body and supported by it. The valve body shall be provided with flanges for bolted connections to similar flanges on the valve body extensions. The valve body and disc shall be machined only after it has been subjected to stress-relieving heat treatment.

The valve body shall be designed to avoid any abrupt changes in velocity. Water passage may be so shaped so as to give either constant velocity or gradual increase in velocity in the direction of flow. Minimum loss of head shall be kept in view while designing valve body, disc and extensions.

4.5.3.2 Foundation

The concrete foundation shall be designed and provided by the civil contractor in the first stage concrete. The Contractor shall design the necessary anchoring to the concrete structure for most severe load conditions. The valve body shall be provided with integral supporting feet designed for transmitting the full load, including the weight of the flanged extensions and contained water, servomotor thrust to base plates secured in the concrete pedestals. Provision shall be made in the valve feet for minimum 8-10 mm movement of the valve body assembly along the horizontal limb of pressure shaft axis. The necessary base or sole plates complete with anchor bolts shall be furnished.

4.5.3.3 Valve Seals and Seats

The material for service seal & maintenance shall be of rubber. Other type of proven sealing arrangement/ sealing material in respect of service and maintenance seal can also be accepted subject to Employer`s approval.

The sealing surface shall be so designed /constructed that there is no jamming when water is drained from the pressure shaft under full head and there is minimum damage on the seat and the seal.

The service seal adjustment feature may be accomplished by seal retaining elements from the downstream side of the valve. It shall be possible to adjust and replace the service seal from downstream side with the Butterfly valve closed.

The seal retainers, seal seat and fasteners shall be of 13Cr-4Ni stainless steel. The seals and the seats shall be designed and constructed of such material that they shall provide maximum tightness, maximum resistance to the silt, minimum maintenance, minimum leakage, convenient adjustment and replacement.

4.5.3.4 Permissible Leakage

Maximum permissible leakage from the service seal shall not exceed one (1) lpm/meter periphery of seal.

Maximum permissible leakage from the maintenance seal shall not exceed three (3) lmp /meter periphery of seal.

4.5.4 Flanged Extensions and Erection Joints

4.5.4.1 General

The valve shall be furnished with two valve body extensions, one for the inlet side of the valve and another for the outlet side. The extensions shall be of plate steel construction, designed for a hydrostatic pressure of 12 bars.

All necessary nuts, bolts and gaskets for the flanged connection between the valve body and the extensions shall be furnished by the Contractor. No special supports shall be provided for the extensions. Their weight, including contained water shall be carried through the flanged joints to the valve body.

4.5.4.2 Upstream Connection

The valve body inlet extension shall be provided with bolting flanges at one end for connection to the valve body. Extra length to accommodate any variations in the distance between upstream horizontal limb of pressure shaft and valve flange for connecting the inlet extension to the valve body shall also be included in scope of supply. The connections of the extension to the pressure shaft shall be of welded type. The Contractor shall cut, chamfer and weld together the end of the pressure shaft and the valve extension including all necessary NDT or heat treatment. Limit of supply from the valve center line shall be finalized during detailed engineering

The material of the pressure shaft shall be ASTM A1537 cl.1.

4.5.4.3 Downstream Connection (Flexible Couplings)

An extension pipe with sleeve type coupling (not transmitting any axial load) of an approved type shall be furnished to connect the valve to downstream horizontal limb of pressure shaft. The coupling shall allow the valve to be displaced 115 mm along the pressure shaft axis due to hydraulic forces and thermal expansion/ contraction to facilitate erection and dismantling of the extension pipe for replacement of the valve seal. The extension pipe shall be complete with all necessary steel flanges, seals or gaskets and coupling bolts.

The surfaces of the coupling in contact with the seal, extension piece and the seal groove shall be plated with stainless steel overlay of minimum 15mm thick.

4.5.5 Valve Disc and Trunnions

4.5.5.1 Valve Disc

The valve disc shall be made of cast steel in one piece, or of welded plate steel construction, or a combination of both, ruggedly designed and heavily ribbed internally to minimize deflection under load in the closed position. The flow passage shall be such that any head losses and flow disturbances can be reduced to a minimum. The disc shall be machined at its rim and provided with an approved replaceable type rubber seal.

The surfaces of seat of the seals in contact with the disc, flange and body shall be plated with stainless steel lining/overlay of minimum 15 mm thick.

4.5.5.2 Trunnions

The trunnions shall be made of forged or cast steel, and shall be welded to the valve disc. The disc and trunnions shall be designed to sustain maximum differential pressure across the valve in closed condition and emergency condition. The trunnion bearing and seal surfaces shall be provided with replaceable stainless steel sleeves. Appropriate seals shall be provided at the outside ends of the trunnion to prevent leakage. The design and construction of the seals shall be based on a recognized design giving due regard to dependability, long life, and convenient replacement.

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4.5.6 Main Bearings

The main bearings shall be self-lubricating sleeve type, supported integrally within the valve body. The bearings shall be designed and constructed so that all necessary adjustments may be made from outside the bearing housings. The bearings shall be of corrosion resisting material and shall be designed so that deflection and trunnion slope caused by the water load on the disc in the closed position shall not result in binding between the trunnions and bearings. The bearing shall be built into the valve body and shall transmit the loads to body. The bearings of either side shall be interchangeable. The main bearing shall be designed for its replacement in situ.

4.5.7 By-Pass Assembly

Each Butterfly valves shall have two (2) number of by-pass assembly of minimum DN 200 complete with hydraulically operated valve, piping and necessary electrical controls. Each bypass valve shall have hand operated guard valve at upstream side and isolating gate valves at the downstream side along with piping. The opening and closing of the bypass valve shall be controlled by hydraulic pressure from the oil pumping unit.

Sizing of the bypass assembly, guard valve, isolating valve and piping shall take into account to maintain balance condition. The by-pass assembly shall be properly supported to minimize vibration and noise. Suitable size diffuser to be provided in bypass pipeline.

The by-pass valves, isolating valves and guard valves shall be of cast or forged steel with wearing parts of corrosion resisting material. A hand wheel mechanism for manual operation of the bypass valve shall also be provided.

The by-pass line shall be used for filling the pressure shaft and equalizing the pressure across the butterfly valve disc before opening.

4.5.7.1 Pressure Gauge and Switches

Necessary pressure gauges, pressure switches, pressure transducer including differential pressure gauges & switches shall be provided for visual measurement and to accomplish specified controls in the upstream and downstream side of the valve disc.

4.5.7.2 Piping

The by-pass piping shall be of stainless steel heavy duty with flanged connections. The necessary bolts, nuts and gaskets shall be furnished by the Contractor to make the system complete. The pressure rating of valves shall not be less than PN 40.

4.5.8 Valves

4.5.8.1 Air Inlet and Vent valve

One or more automatic combined air admission and air release valve(s) complete with a service gate valve(s) and the necessary bolts and gaskets shall be furnished for installation on top of the downstream extension pipe. The size of the valve shall be as required to exhaust the air trapped in the pressure shaft when the by-pass valves are opened for filling the pressure shaft and to admit air when the Butterfly valve is closed and the pressure shaft is being drained. The air and vacuum valve shall be designed to prevent any water spray during its operation.

4.5.8.2 Pressure Shaft Drainage System

The penstock including pressure shaft (downstream portion of Butterfly Valve) shall be drained by means of dewatering valves. In order to evacuate the remaining quantity of water from upstream horizontal limb of pressure shaft, a pressure shaft drainage system shall be installed. One no. heavy duty gate valve of suitable size, made of forged steel, along with one additional guard valve shall be provided. The drain arrangement shall have adequate flexible coupling arrangement to cater the thermal expansion/ contractions of the pressure shaft.

The drain pipe shall be seamless carbon steel of minimum schedule 80. The pressure rating of the valves shall not be less than PN 40.

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4.5.9 Operating Mechanism

The butterfly valve operating mechanism shall consist of two double acting servomotors with base plate anchor bolts and connecting linkage for opening and closing by oil pressure. The lever shall be made of steel and shall be keyed to the valve trunnion. The operating mechanism shall have sufficient capacity to move the valve disc smoothly through one full opening and two closing strokes under conditions specified in Clause "Operating conditions", with the minimum operating oil pressure.

The operating mechanism shall be of sufficient capacity to close the valve in 415 seconds. The opening time shall be approximately equal to the closing time. The closing and opening times shall be adjustable between 415 and 120 seconds with positive means for locking these adjustments.

The minimum permissible closing time shall be controlled by a fixed orifice installed directly at the servomotor outlet as to prevent fast closure of the valve in case of oil piping failure. The Butterfly valve shall be opened normally in balanced conditions or with a maximum difference of pressure of 150% between both sides; however, the valve shall be designed to be capable of opening under unbalanced conditions at maximum flow.

The angular travel of the disc shall not be more than 900 from open to shut-off position.

The operating mechanism shall include suitable positive stops to limit the disc travel at the fully opened and fully-closed positions. A mechanical position indicating device shall be provided on the operating mechanism to indicate the position of the valve disc.

Provision shall be made to manually lock the Butterfly valve in closed position. Lock shall be capable of holding the butterfly valve in the closed position against full combined force of both the servomotors. Parts with sliding contact shall have self-lubricating bushing and corrosion resistant shafts with surfaces finish and coating as required.

All pilot and control valves, limit switches and interlocks necessary to coordinate the operation of the lock with the Butterfly valve and bypass valves sequence of operation shall be provided. When the valve is locked in the closed position, the electric circuits for opening the valve shall be inoperative. Provision shall also be made for padlocking the locking device when in the closed position.

The supply shall include the hydraulic control system complete with the necessary valves, piping, fitting and filters etc. for the operation.

4.5.9.1 Servomotor

The double acting servomotor cylinder body shall be accurately bored to receive the piston. The servomotor shall be provided with suitable gaskets or seal rings designed to remain oil tight at maximum operating pressure.

The operating cylinders shall be sized to open and close the valve with minimum system oil pressure and to retard closing under the most adverse combination of counterweight force and hydraulic torque on the valve rotor due to emergency closure at maximum turbine discharge without exceeding the cylinder design pressure.

The piston rod connecting the piston to the operating linkage shall be hardened, corrosion resistant steel and shall be provided with hard chromium layer. The pistons shall be provided with approved type packing and metal piston rings suitable for the required oil pressure service.

There shall be positive margin in the cylinder with respect to full stoke length or any other alternate arrangement either in piston or cylinder for avoiding seizing of Servomotor when fully opened for longer period.

4.5.9.2 Counter Weight

The counterweights shall be sized to provide net closing torque on the valve rotor under all possible operating conditions. Counterweight shall be segmented plate with smooth finish.

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4.5.10 Oil Pressure System

4.5.10.1 General

Each unit shall have an independent oil pressure system for operation of the butterfly valve for the operating mechanism, servomotor and controls. The oil pressure system shall consist of a sump tank, two (2) AC motor driven screw pumps of suitable capacity, pipes, fittings etc.

The design shall be compact, and there shall be easy access to all the components for maintenance and replacement. All the components shall be selected to assure high reliability, long life, low noise and minimum heating of the oil.

4.5.10.2 Operating Pressure

The normal operating pressure of the oil pressure system shall be approximately 100 - 120 bars and medium shall be nitrogen/oil.

4.5.10.3 Oil Pumps

Mounted on the oil sump tank, two oil pumps shall be provided, one acting as “main” and the other as “standby”. Each oil pump for the oil pressure supply system shall be independently driven by a 3-phase 415V AC electric motor and each shall have a capacity sufficient to operate the complete Butterfly valve oil pressure system. A complete pump logic control system shall be provided that shall permit the selection of either pump, as the main unit with the other pump acting as a standby, which shall cut in automatically to supply the oil and close a set of alarm contacts.

Each pump shall have following devices/ provisions:

i) One electrically controlled loading/ unloading valve at the outlet, so that it discharges to the sump at reduced pressure or accumulator. It shall be possible to run one main pump continuously without overheating the oil,

ii) At the outlet, one safety valve which shall be adjusted to open at more than the maximum operating pressure as per manufacturer recommendation and shall be sized to pass the pump full flow with pressure increase less than 10%,

iii) Hand operated valves at the outlet of the pump, to permit isolating of pumps from the oil pressure,

iv) A suitable oil strainer in the suction line.

Each main and standby oil pump shall be of the screw type, with a capacity (l/ minute) of not less than 1.15 times of the total active oil volume of both the servomotors per minute or higher when operating under the pumping pressure recommended by the Contractor. Each pump shall be self-priming under maximum oil pressure.

Each pump shall be direct-connected to a 415 V, 3 phase, 50 Hz, squirrel- cage, low starting current, induction type motor designed for full voltage across the line starting and conforming to IEC standards, with class F insulation. The motor shall have windings with moisture and oil-resistant insulation. The windings shall be braced for line start application. The capacity and torque shall be suitable for the pump requirements.

The pumps operation shall be as follows:

i) No load starting by returning the oil flow through a unloading valve,

ii) In case of pressure drop, the main pump shall start and keep the pressure within the operating limits by closing and opening the unloading valve i.e. restore the pressure and then stops,

iii) In case of excessive pressure drop the standby pump shall start, both main and standby pump running together shall restore the pressure and then stop,

iv) In case of failure of main pump, the standby pump shall automatically be considered as main,

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v) Automatic changeover from main to standby on the basis of set time running hours,

vi) All valves and mechanisms shall be accurately set and tested in the shop before delivery.

Combination heavy-duty magnetic starting contactors with fused disconnecting switches and three thermal overload devices shall be furnished and shall be mounted on or adjacent to the pump units.

A 415/240 V control circuit transformer shall be provided within each magnetic starter enclosure, of suitable size for control of the starter and supply to the starter accessories. Suitable terminal blocks with marking strips shall be provided in accessible places for the control wiring. All control equipment shall be suitable for operation from the 220 V control circuit transformer. The control equipment shall include a timer, adjustable from 0 to 60 seconds which shall prevent simultaneous closing of the magnetic starters when the power supply is removed and then restored.

A manual control switch shall be provided to select one of the two pumps as the lead pump. An alarm shall be provided to indicate continuous running of the lag pump over an adjustable period of time.

The un-loader valves shall be operated from the pressure accumulator pressure by pilot lines, complete with isolating valves and filters or by pressure switches and shall be equipped with "snap" action pilot valves. Hand-operated valves shall be provided to permit isolating pumps from the oil pressure. Adjustable temperature switches with two (2) electrically separate contacts suitable for operation at appropriate DC voltage located in the sump tank for oil high temperature alarm shall be provided.

The connections to all pumps shall be arranged so that any pump may be removed for repair or replacement without interfering with the continuous operation of the system.

4.5.10.4 Oil Sump Tank

The butterfly valve system shall be supplied with a sump tank of sufficient capacity to hold at least 10 percent more than the total quantity of oil in the entire inlet valve system including oil pressure accumulator. The sump tank shall be designed and have connections for venting and overflow.

The sump tank shall be provided with a manhole of 1500 mm diameter with a suitable oil resistant gasket for access to the interior of the tank. A suitable oil level glass shall be provided to indicate the level of the oil in the tank, marked with low and high level marks, complete with both hand shut-off valves and automatic means of shutting off oil discharge in the event of breakage.

Suitable connections for filling and draining the tank, and connections for an oil purifier shall be provided. The oil purifier connections shall consist of two pipe outlets and valves, one located near the bottom on one side and the other near the top on the opposite side. A vertical filter screen shall be arranged to divide the sump tank into "clean" and "dirty" oil compartments. All strainers shall be readily removable for cleaning. The outlets of all oil pipes to the sump shall be below low oil level. Any component that requires adjustments shall not be located inside the sump tank. Low and high level switches shall be provided for sump tank, suitable for appropriate DC voltage, which operate alarms whenever the oil level reaches the present level. An oil temperature switch wired to cut off power supply to the oil pumps in the event of high temperature shall also be provided. Moisture indicating device shall also be provided for moisture indication.

i) **Proportional valve oil filtering**

Suitable dual online oil filter with changeover and clogging indication shall be provided in Butterfly valve actuator supply circuit to ensure that impurities as recommended by the manufacturer are avoided. Clogging indicators with electrical contacts to indicate the clogging of filters shall be provided. Filter elements used shall be cleanable with Petrol.

ii) **Main circuit oil filtering**

One oil filter shall be provided in the pumps unloading discharge line to ensure the main circuit impurities as recommended by the manufacturer are avoided. Clogging Visual indication with electrical contacts to indicate the clogging of filter shall be provided. Filter elements used shall be cleanable with Petrol and easily changeable. Main circuit oil filter shall be equipped with one automatic by-pass allowing operation in case of clogging of the filter element.

The filter system shall be able to handle the discharge flow of both main and standby Pumps.

4.5.10.5 Hand Operated Pump

One hand operated pump shall be provided for emergency operation of BFVs and building up of system pressure in each of the pumping sets.

4.5.11 Oil Pressure Accumulator

4.5.11.1 Capacity

The pressure accumulator shall have a total volume of at least twenty five (25) times the combined active volume of the two servomotor cylinders of the Butterfly valve and shall be designed for a pressure ten (10) percent above the actual maximum system pressure. The size of the accumulator shall be such that it shall be possible to operate the Butterfly valve three (2) times (1 “C” +1 “O”) from minimum normal oil pressure without the operation of Butterfly valve oil pumps and without dry nitrogen admission. At the remaining pressure the inlet valve mechanism should still operate with a safe margin.

4.5.11.2 Construction and Safety Features

The accumulator shall be of piston type. It shall be constructed from plate steel conforming to ASTM A 1516 grade 70 or higher in accordance with part UW of the ASME Code for Unfired Pressure Vessels, Section VIII, for the maximum working pressure of the system.

The accumulator shall be painted on the inside and on the outside as per approved painting system. Thickness of inside painting shall be such that these do not flake off during operation. Prior to shipping, all threaded openings shall be closed with standard pipe plugs. Flanged openings shall be protected with blind flanges with gaskets bolted in position.

All connections to the pressure accumulator, with the exception of the nitrogen supply and the upper gauge connections etc. shall be made below the low oil level and shall be designed to prevent foaming. Bypass valves shall be provided to drain the pressure accumulator into the sump for cleaning or repairs.

The accumulator shall be equipped with a pressure gauge, a safety relief valve, pressure transducer, burst disc and at least two (2) oil-level sight gauges metallic magnetic float pipe type with indication, switches and transmitter. The safety relief valve shall be set to open at 110 percent of the maximum operating pressure of accumulator. The sight gauges shall be long enough to overlap the high and low oil levels by at least 150 mm. The safety relief valve should release nitrogen to atmosphere in a manner not injurious to personnel or equipment in the vicinity of the accumulator.

The accumulator shall be provided with a float/isolating valve assembly to prevent nitrogen admission into the inlet valve oil piping system under conditions of low oil level.

The accumulator shall be provided with an automatic nitrogen admission system to maintain a proper proportion of the nitrogen cushion volume. Manufacturer shall supply all necessary piping, fittings, solenoid-controlled valves, pressure and level switches required for this system. The solenoid shall be suitable for operation at appropriate DC voltage and completely wired.

Pressure switches shall be of approved make. In addition to echelon control, the following provisions shall be made for each pressure accumulator:

i) Normal pressure signal for unit start interlock,

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ii) Inlet valve oil low pressure alarm to the station annunciator,

iii) Extreme low-pressure trip and unit shutdown interlock,

iv) Automatic nitrogen admission.

All Instruments necessary for proper and safe operation of the unit shall be supplied with at least:

i) One oil pressure transmitter,

ii) One oil level transmitter with switch for normal oil level unit start interlock,

iii) Low level switch – alarm,

iv) Low level switch – Unit trip,

v) Very low level switch – Unit trip and close isolating/ float valve.

All transmitters shall be 4 to 20 mA type. Contractor is free to use individual suitable pressure and level switches. In this case, all contacts shall be adjustable electrically separate and suitable for appropriate DC voltage operation.

The pipe connections for all pressure and level switches shall be independent of the oil supply lines to the servomotors and shall be provided with individual shut off valves and bleed valves as necessary.

In addition to above, one pressure transducer for nitrogen gas shall be installed for monitoring the nitrogen gas pressure through plant SCADA System.

4.5.12 Miscellaneous Components

4.5.12.1 Lifting and Handling Fixtures

The Contractor shall provide lifting fixtures and special tackles and devices for handling of major components of Butterfly valve like valve body, disc, transition sections, servomotors, counterweight, bearings etc. These devices shall include at least the following:

i) One (1) valve handling and lifting device for handling and lifting the assembly of valve in-situ,

ii) One (1) valve disc lifting device and set of special nylon slings for lifting and handling the valve disc, servomotors, levers, counterweight etc.

4.5.12.2 Nameplate

A rating nameplate of stainless steel material shall be attached to each major item of equipment supplied. This plate shall be permanently engraved with the designed full load ratings, serial number, type number, date of manufacture and other identification deemed necessary. Hydraulic and electric control system diagram plates shall also be supplied. The material and the identifying inscription shall be approved by the Employer.

4.5.12.3 Access Platforms and Stairs

Walkway, platform, staircases, handrails etc. shall be provided for convenient and safe access to all operating equipment and points of lubrication. Also chequered plate/ grating covers shall be provided for opening/ trenches for cable, cable trays, pipes, ducts or any other trench/opening required for completing the floors around and over the works supplied under the contract.

The material for all handrails shall be stainless steel. Gratings for hatches, platform, walkways, staircases etc. shall be factory made; galvanized and fabricated mild steel electro forged conforming to relevant standard.

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4.5.13 Auxiliary System

4.5.13.1 Oil and Water Piping

All Oil piping shall be seamless stainless steel of minimum schedule 80 except drain which shall be stainless steel and shall include all piping to the oil pressure supply system consisting of sump tank, pressure accumulator, servomotor, cabinet instrumentation etc. as required. The piping shall be of such size that the maximum oil velocity shall not exceed 3.0 m/sec in the pressure lines and 1.15 m/sec in the return lines. Minimum pressure anywhere in the oil piping system during maximum speed of valve operation shall not be less than 0.15 bar absolute.

The entire piping system shall be welded, insofar as practicable, leaving only such flanged connections as may be necessary for erection or possible subsequent dismantling for repair.

The piping shall be thoroughly pickled, cleaned, and the interior coated with oil before shipment. Prior to shipment, blind flange with gaskets on the flanged connections, screwed caps on the threaded ends and suitable plugs in plain ends shall be provided to prevent the entrance of foreign matter into the piping during shipment or while awaiting installation.

Water piping shall be made of heavy duty seamless steel pipe and shall have flanged connections as may be necessary for erection or possible subsequent dismantling for repair

4.5.14 Control and Monitoring

The Butterfly valve and associated accessories/ equipment shall be controlled and monitored at two levels:

i) By respective local control cubicles,

ii) By Control and monitoring (SCADA) system through Unit Control cubicles.

iii) Hardwired emergency closing of Butterfly Valves from Control Room.

The Contractor shall make provision of contacts and/or ports in local control cubicles for interfacing with SCADA system for control and monitoring.

The normal control by the SCADA system shall be through Unit Control Cubicles. It shall be the responsibility of the Contractor to make all necessary provisions required to achieve seamless and compatible interfacing of the system with SCADA system.

Local control shall be performed in an independent and standalone manner, and all information (faults, alarms, measurements, status) necessary for such control shall be displayed locally. If the system consists of redundant subsystems, the priority of operation of such subsystems shall be selectable either from SCADA system or locally.

4.5.14.1 Instrumentation

Indicating instruments as required shall be installed on local control panel and indications may be replicated in control room for common services.

The Butterfly valve control system shall be provided with at least the following to accomplish the specified alarm, indications and interlocking function:

i) Pressure gauges, pressure transducers and switches for measurement and detection of the pressure in the pressure shaft and upstream transition section,

ii) Differential pressure switch and gauge for upstream and downstream valve disc pressure,

iii) Suitable nos. of pressure and level switches/ transmitter for auto operation of the pumps, nitrogen admission start-stop and annunciation purposes in the accumulator,

iv) Auto selection of OPU pumps on account of running time and mechanical & electrical fault,

v) Level switches and level indicator for sump tank and accumulator,

vi) Linear displacement transducer (LDT) for position and velocity measurement of the accumulator piston,

vii) Non-contact type position switches for fully open, partly open, partly closed and full closed valve position for the butterfly valve,

viii) Non-contact type position switches for fully open and fully closed, position of by-pass valve,

ix) Non-contact type position switches for indication/ interlocking purposes for the valve manual locking mechanism,

x) Non-contact type position switches for detection of engaged- released position of valve maintenance seal,

xi) Electromagnetic type flow meter between hydraulic bypass valve and guard valve,

Any other instrumentation required during detailed engineering shall be provided.

4.6 Performance Criteria & Guarantees

4.6.1 Performance Guarantee

The Butterfly valve along with all auxiliaries and accessories shall be capable of performing intended duties under specified conditions and in Data Sheets of Volume-6. The Contractor shall guarantee the reliability and performance of the individual equipment as well as of the complete system. The Butterfly valve along with upstream connection and downstream connection shall be shop tested at a pressure 1.5 times the design pressure.

4.7 Tests

4.7.1 Shop Assembly and Tests

4.7.1.1 Assembly

Before being painted the disc of each butterfly valve shall be completely assembled in the valve body with the packing glands, disc seal etc. and when so assembled shall be given an overall performance test and pressure tests. All components/sub-assemblies shall be match marked and doweled to ensure correct assembly and alignment in the field.

4.7.1.2 Performance Tests

After the final assembly, each valve shall be shop operated three times from fully closed to fully open position and vice versa under no pressure and no flow condition to demonstrate that the assembly is workable.

4.7.2 Material Tests

The material test includes chemical analysis, mechanical tests and non-destructive tests.

i) **Chemical Analysis**

For all main components and components exposed to high stresses and/or conditions where the composition is of importance, chemical analysis of the material will be carried out in accordance with normal practice to verify that the components conform to the required specification.

ii) **Mechanical Tests**

Mechanical tests will be carried out on all main components according to the normal practice and relevant standards to ascertain that material properties conform to the requirements and specifications. Such tests include the determination of the yield strength, UTS, elongation/contraction and impact strength in aged/non-aged condition as required. Bend test of plates and sheets will also be performed as required.

iii) **Non- Destructive Tests**

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Sl. No.	Test
1	Non-destructive tests include ultrasonic tests, X-ray tests, magnetic particle tests and dye-penetrant tests.
2	The test of visual examination will be carried out on all principal castings and forgings which are subject to, or affected by, high service stresses. Major defects, if any, will be removed by suitable means and soundness of metal will be checked by means of magnetic particle or dye penetrant inspection.
3	Plates which are subjected to high service stress impact, fatigue or vibration stress will undergo visual inspection and ultrasonic testing prior to use for manufacture and welding.
4	Welds shall be 100% radiographically tested. Alternatively, these shall be subjected to ultrasonic examination. Defects in welds disclosed by ultrasonic or radiographic testing or dye penetrant or magnetic particle testing will be completely removed by chiseling and after re-welding, the new weld will be again subjected to radiographic examination.
5	The section VIII of the ACME 'Boiler and Pressure Valves Code will be applicable for the above tests.

4.7.3 Tests on Steel Plates

Steel plates used for manufacture shall be certified by the steel plate's producers, highlighting the following information:

Sl. No.	Test
1	Charge No.
2	Chemical analysis of the melt
3	Plate thickness and size.
4	Following tests along rolling direction.
	i) Yield strength, tensile strength and elongation rupture.
	ii) Three ISO, V-notch toughness test at 0oC in the thickness direction.

The findings will conform to minimum requirements of the specifications for the material approved for the relevant structure.

Ultrasonic tests will be made on all plates subject to lateral stress.

4.7.4 Measurements

All Butterfly valve components shall be given the following checks, wherever applicable, in respect of

Sl. No.	Item	Measurement
1	Body and disc	Dimensional checks.
2	Servomotor	Stroke, free Movement, pressure tests.
3	Oil pressure unit	Hydraulic pressure tests, operation tests.
4	Electro-magnet valves.	Working operation test.
5	Important castings/ forgings/ plate-structures.	Material tests (Mechanical and chemical composition).

All motors, accessories and auxiliary equipment forming part of valve shall be tested in accordance with the requirement of the latest relevant standards. Each mechanical and electrical sub-assembly shall be tested for proper functioning and continuity of the electrical circuit.

A list of all items for inspection and testing, shall be furnished by the contractors in the bid.

On auxiliary equipment viz. pumps motors etc., routine and type tests shall be carried out in the shop as per standards and test certificates shall be submitted to the purchaser for approval before dispatch.

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4.7.5 Pressure Tests

All parts containing liquid or gases, subjected to internal or external pressure temporarily or permanently during operation will be tested prior to painting as per relevant standards. As far as possible these tests shall be done in the shop.

Pipe system will generally be pressure tested with water.

The test pressure will generally be 150% of the design pressure of 125.0 m. The pipe system will be cleaned thoroughly before tests.

Embedded system shall be pressure tested before embedding.

The components which operate under pressure of water, air etc. (excepting those which cannot be pressure tested in shop) shall be subjected to hydrostatic pressure tests in shop using a test pressure of 150% (one hundred & fifty percent) of the design head of 125 m for a duration of not less than 30 minutes.

Each valve shall be tested with water as the test medium and shall be subjected to the following tests:

i) **Body Test**

With both ends closed either by full end covers or by hollow cylindrical covers and the disc slightly open, hydrostatic pressure of 187.5 m, i.e. one and half times of the design pressure. The pressure shall be maintained for a period of at least 30 minutes. Under this test, there should be no leakage from the interior of the body, bolted connections, welding joints and glands. The body shall be hammered several times during this test.

ii) **Disc and Seal Test**

Hydraulic pressure of 187.5 m.w.c shall be lowered to the design pressure of 125.0mwc and maintained for 30 minutes with one end open to the atmosphere and the disc in closed position. After that the pressure and leakage shall be measured. The method of measuring the same shall be stated. The leakage shall be measured and shall be within guaranteed values.

In order to carry out above tests, the contractor shall make adequate provision in his bid to supply all necessary equipment, apparatus such as bulk heads, pumps, piping, valves, gauges, oil etc. as and when required.

In addition to above, all other hydraulic and control equipment's for the valve shall be tested for satisfactory operation by the contractor in a manner suited to the type/design of equipment and control furnished as approved.

4.7.6 Field Tests

All welding done at site shall be subjected to 100% radiographic/ultrasonic examination to detect cracks, blow holes etc.

All essential tests, at site shall be performed on the Butterfly Valves during the course of assembly, erection, pre-commissioning and commissioning. The contractor shall furnish a comprehensive and exhaustive list of all such tests for approval.

The following inspection and tests shall be carried out at site on each Butterfly valve after erection & commissioning of each valve:

Sl. No.	Test	Details
1	Inspection	All components are to be inspected to ensure that these are in sound condition.
2	Operational	The following checks shall be conducted under 'No pressure' & 'No flow' conditions: Operational time for closing and opening of valve. Operation of by-pass valve, air vent and anti-vacuum valve.

		Nuts and bolts tightness, verification and proving its soundness.
3	Leakage test	This test shall be carried on service and maintenance seals for leakage within guaranteed limit at 12.5 kg/cm2 (125 m.w.c).
4	Pressure test	Pressure test at 18.75 kg/cm2 (187.5 m.w.c). Bulk heads shall be provided by contractor.

4.7.7 Acceptance Tests

The equipment, associated accessories and controls of the valves, complete in all respects shall be subjected to satisfactory acceptance tests, to be carried out by the contractor after completion of the installation at site, commissioning adjustments, if any. Acceptance tests of Butterfly valve and its controls shall be spanned over a reasonable period of satisfactory operation of the entire system as a whole to establish fulfilment of various design requirements as per these specifications.

While necessary electric power shall be supplied by the purchaser, necessary hydraulic oil, all special tools, tackles, gauges, meters, instruments and apparatus etc., required for acceptance tests shall be supplied by the contractor which shall ultimately become the property of the purchaser

The successful completion of acceptance tests for the valve will not in any way absolve the contractor of his responsibility for any damage/defect that may develop due to normal operation of the equipment, accessories and controls of the valve within 36 months of the final acceptance tests where such damage may be due to faulty design, defective materials, or components supplied whether fabricated, manufactured by the contractor or otherwise arranged by him as bought out items) and/or bad workmanship.

These tests and inspection shall demonstrate the following:

Sl. No.	Description
1	Materials used for various and vital components have required strength and composition.
2	Good workmanship.
3	Pressure tightness of sub-assembly and assembly.
4	Equipment and components operate smoothly and suitably within specified time.

4.7.8 Test Reports

Shortly after completion of the field acceptance tests the Contractor shall prepare and forward draft copies of the field acceptance test report to the Employer for review. After review and acceptance, the contractor shall furnish six (6) copies of the final report.

4.8 Drawings, Documents and Design Calculations

4.8.1 Design Memorandum

The Contractor shall submit to Employer a design memorandum prepared in accordance to clause 2.5 “Design Memorandum”, of General Technical Specification.

4.8.2 Drawings and Documents

The Contractor shall submit all the drawings and documents in accordance with requirements stipulated in clause 2.6 “Drawings & Documents to be supplied by Bidder” of General Technical Specification.

4.8.3 Design Calculation

The Contractor shall submit the design calculation in accordance to clause 2.6.4 “Design Calculations” of General Technical Specifications, Volume-4 covering at least the following, for review/ acceptance:

i) Structural and stress analysis of different parts of main Butterfly valve components in all loading conditions,

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ii) Calculation of hydraulic forces and torque on the valve disc, trunnion and body during opening and closing of the valve for different positions of the valve and different turbine flow conditions,

iii) Calculations of sizing of bypass valve,

iv) Calculations of foundation loads,

v) Oil pressure system pump-motor capacity calculation,

vi) Calculation of sizing of inlet valve servomotor,

vii) Size and plate thickness calculation for accumulator and piping,

viii) Sump tank sizing calculation,

The Contractor shall also provide other calculations as required by the Employer for his approval of the Contractor's design.

4.9 Delivery, Installation and Commissioning

The Contractor shall follow the general requirement of Delivery, Installation and commissioning as per relevant clauses in General Technical Specification.

4.10 Schedule of Requirement

Design computations, drawings, manufacture, testing at manufacture's works, packing, forwarding, transportation, insurance, preservation at site till installation, erection, testing and commissioning etc. of Butterfly valves along with the associated auxiliaries which shall broadly comprise of:

Sl. No.	Description	Unit	Qty.
1	Butterfly valves, 3300 mm dia, suitable for 100 m Design head, 45 m3 /sec. normal discharge and emergency closure under various conditions complete with servomotors and all air release valves, anti-vacuum valves, by-pass valves, over velocity devices, counterweight and operating mechanism forming part of the valves for its operation as per this specification.	Nos.	2
2	Foundation and fixing arrangement etc. such as bolts, nuts, washers, pipes, turnbuckles, jacks, sole plates etc. for the above mentioned Butterfly Valves.	Sets	2
3	Dismantling joints for disassembly of the Butterfly valves for maintenance and removal as detailed in these specifications.	Nos.	2
4	Upstream and downstream connection pipes for joining the Butterfly valve to the pressure shaft steel liners complete with flanges, bolting materials and gaskets/ 0-seals etc., as per specifications.	Sets	2
5	Valve operating power packs for pressure oil system, consisting of pressure oil supply equipment for supplying oil at max. 100 kg/cm2 comprising oil pump sets, oil sump tank, automatic valves, check valves, manual valves and internal piping, bladder type pressure accumulators.	Sets	2
6	Valve control panels or boards for the operation of the valves locally from the valve house as detailed in the specifications.	Sets	2
7	Remote control panel mountings & interfaces for status indications and emergency closing of both the valves to be mounted in powerhouse and control room panels along with interconnecting control cables from valve house to power house.	Sets	2
8	Associated spares and tools etc.	Lot	1
9	Spares for valves as per schedule of mandatory spares.	Lot	1
10	Special tools tackles, slings for assembly, testing, handling of Butterfly valves at site and for disassembly during maintenance.	Lot	1

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Sl. No.	Description	Unit	Qty.
11	Auxiliary equipment comprising grease drum, grease gun, grease hose, nipples and pipe connection etc.	Set	1
12	Consumables for site assembly, erection, testing and commissioning of Butterfly valves.	Lot	1
13	Other miscellaneous services as detailed below:		
i)	Insured marine transportation of the Butterfly valves from port of dispatch to port of entry in India including port handling and other charges at port of entry in India in case of foreign supply.		
ii)	Insured inland transportation from port of supply in India or works in India to the designated stores.		
iii)	Storage and preservation of Butterfly valves at site till site assembly, erection, testing and commissioning of both the valves.		
14	Complete assembly, erection, testing and commissioning at site including welding of connecting upstream downstream pipe pieces.		

Any item of supply not explicitly listed but otherwise either implied by the contents of the specification or essential for smooth operation of the equipment shall be construed as forming part of the supply and no additional charges shall be payable for the same.

As and when any particular item/s which was not explicitly listed are found to be essential, the contractor shall affirm the inclusion of the same in the scope of supply without any extra charge.

4.11 Spare Parts

Recommended spare parts shall be supplied in accordance to clause 3.0 “Spare Parts and Tools” of General Technical Specifications. Specified spare parts to be supplied under this Chapter are as follows.

Sl. No.	Description	Unit	Qty.
1	Pressure oil pump motor set	No.	1
2	Ball and roller bearing used in pump and motor	Type	2
3	Un-loader valve complete assembly	No. of each type	1
4	Safety relief valve complete assembly	No. of each type	1
5	Set of Oil filters of each type used in the electro hydraulic actuator and pumping set (except pump suction filter)	No. of each type	2
6	Level switch, level gauge and level transmitter	No. of each type	1
7	Sight gauge assembly for accumulator and sump tank	No. of each type	1
8	Pressure switch	No. of each type	1
9	Thermometer	No. of each type	1
10	Non-contact type position switches	Set	1
11	Pressure gauge	No. of each type	1
12	Servomotor complete	No.	1
13	Butterfly valve seal set each consisting of service seal and maintenance seal including fasteners and seal retainers	Sets	2
14	Hydraulic bypass valve	No.	1
15	Guard valve of by-pass valve	No.	1
16	Set of bushes for main Trunnions	Nos.	2
17	Butterfly valve body drain valve	No.	1
18	Solenoid valve	No. of each type	2
19	Solenoid Coils	Total numbers required for two (2) units	
20	Air vent cum admit valve	No.	1

Sl. No.	Description	Unit	Qty.
21	Oil pump suction strainer/ filter set	Nos.	2
22	Air filter set	No. of each type	2
23	Nitrogen cylinders	Unit	Total
24	Complete proportional valve assemblies	No. of each type	1
25	Control valves	No. of each type	1
26	Transducers assemblies complete of all type used	No.	1
27	Valves of each type (25mm and above)	No. of each type	1

Besides above, the Contractor shall recommend any additional spare parts, which in his opinion are necessary for satisfactory operation of the system. However, the procurement of these recommended spares shall be at the discretion of the purchaser. The additional recommended spare parts shall be indicated in the Data Sheets of Volume-6.

4.12 Guaranteed & Other Technical Particulars

The Contractor shall follow the Guaranteed & Other Technical Particular requirements specified in this specification and separately in Data Sheets of Volume-6.

4.13 Tools and Instruments

The Contractor shall supply all necessary tools and Instruments etc. for installation, repair and maintenance in accordance to clause. 3.2 “Tools and Instrument” of General Technical Specification.

4.13.1 Special Tools

The Contractor shall list and supply all special tools. List of such tools including their make and detailed specification, shall be submitted for acceptance by the Employer besides the following special tools:

i) Two (2) sets of special tools for maintenance and service seal replacement,

ii) Two (2) sets nitrogen leak detector.

4.14 Quality Control and Assurance

The Contractor shall submit detailed Quality Assurance Plan and Inspection Schedule for Employer’s review and approval in accordance to clause 12 of General Technical Specification.

4.15 Deputation of Engineers for Witness of Tests and Inspection

The Employer’s representatives shall be deputed for the following purposes.

Sl. No.	Inspection /Test	Quantity
1	Shop Inspection and Test	Employer’s representatives from time to time

The training of employer’s personnel shall be as specified in clause 11.0 “Training of Employer’s Personnel” of General Technical Specification.

4.16 Deviations from Specifications

All deviations from these specifications shall be separately listed in the requisite Performa of the bid document, in the absence of which, it will be presumed that the provisions of the specifications are fully complied with by the bidder. However, the deviations, which are better than the specifications shall be considered by the purchaser.

4.17 Completeness of Contract

Any fittings, accessories or apparatus required for successful commissioning though may not have been specifically mentioned in the specification but are usually necessary for the

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completeness of the works shall be deemed to be included in the specification and shall be supplied by the bidder without any extra cost to the purchaser.

4.18 Employer's Specification

Sl. No.	Item	Unit	Description
1	Manufacturer		By Bidder
2	Applicable standards		IS 7326
3	Nominal Diameter of Butterfly valve	m	3.3 m diameter (2 no)
4	Direction of flow		Bi – Directional
5	Maximum flow		To suit the maximum flow through the two turbines
6	Minimum flow		To suit the minimum flow through the two turbines
7	Normal operating pressure		Head conditions suiting the operation of Turbine
8	Maximum Static Head	mwc	100
9	Upstream extension piece		Required
10	Downstream dismantling joint		Required
11	Downstream companion Flange		Required
12	Downstream transition piece		As required by the bidder
13	Material standard		
14	Penstock diameter		3.3 m
15	Penstock thickness		16mm (3.3 diameter)

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4.19 Applicable Standards

Sl. No.	Items	Standards
1	Valve body	Carbon Steel to ASTM A 216 Gr WCC/ ASTM A 516 Gr 60, 70 / IS: 2856 / S355J2+N, EN 10025-2 / IS 1030 340 570W
2	Valve disc – Lattice type	Carbon Steel to ASTM A 216 Gr WCC/ ASTM A 516 Gr 60, 70 / IS: 2856 / S355J2+N, EN 10025-2 / IS 1030 340 570W
3	Shaft	Stainless Steel ASTM A 276 Gr 431 Carbon steel ASTM A216 Gr WCC / ASTMA668 CLASS E / P420QH1, EN 10222-4
4	Service Seal	Stainless steel / X3CrNi13-4
5	Maintenance Seal	Stainless steel
6	Body Seat ring	SS 304 / SS415 / X3CrNiMo13-4
7	Seal retaining ring	SS 304 / Equivalent
8	Bearings	Bronze/Teflon Coated DU bushes
9	Fasteners	
10	External fasteners (Integral)	HTS / EN 10250 30 CrNiMO8
11	Internal fasteners (Integral)	SS A4 – 70 / X20Cr13
12	Companion flange	Carbon steel with Cadmium plating / Suitable corrosion protection
13	Upstream extension piece	ASTM A517 Gr F

CHAPTER 5 GENERATOR AND ACCESSORIES

5.1 Scope of Work

Scope covers the design, manufacture, test at works, supply, delivery to site including transit insurance, erection, testing at site, training of Employer's personnel, installation commissioning and handing over to KHPL of Generator units & its accessories, along with, Sliprings and Carbon Dust Extraction System, Vibration and Air gap monitoring system and safety devices (as required) etc.

Four nos. of 3-phase, 150 MW with 10% COL, 13.8 kV Vertical shaft synchronous Generator with complete accessories.

As per CEA guidelines, in underground powerhouse, generator protection shall be water spray type as release of CO2 in underground powerhouse may be hazardous. Alternatively for generator protection, an Inert gas fire suppression system is considered.

5.1.1 Followings are the list of items/systems necessary for each Generator unit

i) Generator

ii) Generator Cooling System

iii) High Pressure Oil Lubrication system for Generator Bearings

iv) Jacking oil system for Generator Rotor Lifting

v) Generator Mechanical Brake system with air pressure operated for breaking

vi) Oil mist extraction system for all Bearings

vii) Generator winding Anti-condensation heating system

viii) Unit gauge and alarm panel with displays for Temperature, pressure, flows etc.

ix) Environment friendly Inert Gas based fire extinguishing as per NFPA guidelines.

x) Generator Stator Temperature Monitoring system for Windings and Core.

xi) Brake dust extractor system.

xii) Mechanical and Hydraulic Over Speed Devices.

xiii) Online monitoring subsystems

xiv) Interconnection cables, cable accessories terminal blocks etc.,

xv) Barrel Illumination system

xvi) One Set of Sole plates, holding down bolts, foundation bolts, dowels etc. for stator erection, levelling and alignment of both types of machines

xvii) Sliprings and Carbon Dust Extraction System

xviii) Generator Testing devices and instruments

xix) Access Doors, Stairs, Walkways, railings and plat forms for easy maintenance along with other metal supporting and covering parts, gratings required for the Generator & its concrete Barrel

xx) Rotor Shaft earthing System

The scope of supply shall include all parts, accessories etc., which are essential for construction, operation and maintenance of the complete generator even though these are not individually or specifically stated. Corresponding components of all the generators and associated equipment's and the spares shall be of the same material, dimensions and finish and shall be interchangeable.

5.2 Code and Standards

The Generator & its accessories such as the excitation system, automatic voltage regulation, cooling system, start-up etc., shall generally comply with the requirements specified in the

national & international standards indicated as per data sheet & additionally comply with specific requirements as indicated below.

The design, material, construction, manufacture, inspection, testing and performance of equipment shall comply with all currently applicable standards, codes of practice, regulations and safety codes in the locality where the equipment will be supplied & installed. Nothing in this specification shall be construed to relieve the CONTRACTOR of this responsibility.

The codes and standards mentioned in the various specifications and requirements specified in the enquiry document shall be latest as on the day of award of contract of the works unless otherwise specified. Contractor shall be responsible to inform to the Consultant/ Owner in case of any revisions/re-affirm/amendment in the relevant codes and standards after the date of award of contract within 30 days of the issue of such revision/re-affirm/amendment of the code/ standard. Consultant/ Owner may approve use of the earlier code/ standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed

In case of conflict between the applicable standards and this specification, the more stringent of the two shall govern

5.3 Specific Requirements

The generator shall be capable of delivering rated output at rated power factor, as specified without exceeding specified winding temperature, when operated continuously under operating site conditions.

The voltage and frequency operating range in percentage rated values shall be as follows:

Voltage variation	: ±10%
Frequency variation	: ±5%
Combined Voltage & frequency variation	: ±10%

The generator shall be designed to give the best efficiency when generating at the rated parameters.

The hydro generator shall be designed for continuous operation with 105% flux as a percentage of flux at rated values.

The generator and auxiliaries shall be designed to safely withstand the maximum runaway speed of the turbine for 15 minutes without causing undue vibrations and damage to the machine and mechanical parts.

The static and dynamic balancing of rotor shall be carried out after complete assembly, including the rotor at 25%, 50%, 75%, 100% and 110% of rated speed and the values of rotor vibrations shall be within allowable limits according to applicable standard.

The generator and accessories shall be designed to withstand all electrical, mechanical, and other stresses which may be experienced during normal operation, short circuit, over speed/runaway speed conditions etc.

The generator shall be designed to run with safety up to maximum possible runaway speed of the turbine under maximum head. It shall be capable of running for a period of 15 minutes at the maximum runaway speed with cooling water system and 10 minutes without cooling water system in service

The stator core shall be designed to withstand an earth fault current and necessary supporting document to be furnished for reviewing / to confirm the design.

5.4 Temperature Rise

i) The rated output at the Generator terminals shall be guaranteed for continuous operation (S1) without exceeding the excess temperature limits admissible according to IEC 60034-1, Temperature rise Class B, insulation Class F, for stator and rotor windings (at

rated voltage, rated power factor, rated frequency, cooling air inlet temperature maximum 40 °C and cooling water inlet temperature 30 °C).

ii) When operating continuously at the generator rated output at 0.85 P.F at 50 Hz, the temperature rise shall not exceed the limits as mentioned in the data sheet-A.

iii) Each generator shall be adequately insulated against stray currents set up by the field of the generator which may cause injury to the generator or turbine bearings. Insulation shall be arranged to break the possible path of shaft currents in not less than two places in series so that positive tests of ground currents can be made readily.

iv) Generator shall be star connected and the main and neutral leads shall be brought out of the stator frame for connection to isolated Phase bus duct. The generator shall be grounded though a suitable rating Neutral grounding transformer (NGT) with resistor in secondary of NGT, to limit the ground fault current.

v) The generator shall be rated for higher output corresponding to the 110% of the rated input at rated voltage, frequency and power factor. The hydro generator shall deliver continuously the rated MVA at rated power factor when operating under rated conditions with temperature rise / temperatures not exceeding Class - B values, stipulated in the latest issue of the IEC 60034-1.

vi) In the design of Generator each part shall be so proportional that the maximum unit stresses therein resulting under any continuous operating conditions shall not exceed 1/3 of the yield point or 1/5 of the ultimate strength of the material whichever is less. In case of specified runaway speeds, unit stresses not exceeding 2/3 of the yield point will be permitted.

vii) The Generator shall be mechanically capable of withstanding sudden short circuit or sudden open circuit at its terminals and load throw off at 110% of rated load.

viii) The Generator shall operate satisfactorily and stably in parallel with the grid with load as Generator and with lead / Lag reactive power contribution. The alternator should remain stable on sudden application of maximum load or sudden loss of maximum load and during momentary short circuits or sustained ground faults.

ix) The GD2 of the generator shall be adequate to keep the speed rise and pressure rise within limits without considering GD2 of other rotating parts and stability. The value of GD2 must be suitable for the speed of the machine and shall be incorporated in the alternator and turbine and not added in the shape of separate weight rings or other means.

x) The inherent regulation of alternators shall be stated in the tender and this shall mean the percentage rise of voltage when full loads are thrown off without changing the speed or the exciting current of the machines.

xi) Each alternator when running at normal speed with excitation for the maximum output at 0.85 P.F. and on automatic voltage regulator control must be capable of withstanding short circuits at its terminals without any displacements of its windings or mechanical damaged to any of its parts. The Sustained single and three phase short circuit currents shall be stated in the tender. The short circuit ratio of the alternator shall not be less than 1.1. Full particulars of the alternator including weight, regulation, line charging current capacity etc., shall be given in the tender.

xii) Each Generator winding Star point shall be earthed through a single-phase grounding transformer and secondary winding of the transformer shall have a parallel resistance of suitable capacity.

xiii) The machine shall be provided with sufficient no. of RTDs and thermocouple type temperature detectors embedded in places where the highest temperatures are likely to occur, and their locations must be clearly stated in the tender. The winding temperature alarm may be operated off the thermocouples in the machine slots through suitable relays. For bearing alarms suitable DTT and thermostats should be provided in both

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thrust and guide bearings. Trip contacts may also be provided to trip the turbine governor and circuit breaker which may be set for a particular temperature limit. Flow relays shall be supplied for cooling water flow alarm.

xiv) The noise level shall not exceed 90 dB (A) when measured at a distance of 1m outside pit/barrel of the Generator.

xv) The generators shall be suitable for parallel operation among themselves as well with grid.

xvi) Generator shall have capability to run in synchronous condenser mode.

5.5 Design and Construction Features

The generator shall be of the vertical shaft water wheel driven synchronous type. The direction of rotation shall be to suit the direction of rotation of Turbine. The Turbine and Generator shall be matched in respect of speed, runaway speed, moment of inertia, coupling and other relevant requirements.

Generator leads shall be brought out of the stator frame for connection of current transformers for protection, metering and surge protection apparatus.

The contractor shall give full particulars of the extent to which the Generator will be assembled for the purpose of the shipment and the full details of the work to be done at site in assembling and the means to be adopted for carrying out these works.

5.5.1 Stator

The stator shall be built such as to limit eddy current losses and to ensure a uniform temperature rise in the core.

The stator frame shall be made from mild steel fabricated construction. Steel plates shall be welded together to make a rigid structure of hollow cylindrical form to accommodate the core. The frames shall be designed to withstand large, short circuit forces without causing any deformation. The stator frame shall be designed with due consideration to prevent generator from resonating with vibrations transmitted from turbine/generator rotor.

The stator core shall be made up of thin, high quality, low loss non grain-oriented silicon steel stampings. Special thin sheets shall be used to minimize losses under operation. Also, the laminations shall be insulated to reduce the eddy current loss. Stampings shall be stacked together in packets separated by ducts, thus increasing the cooling surface and facilitating the passages for cooling. The core body and teeth shall be compressed hydraulically between thick mild steel plates.

The stator windings shall be double layer lap arrangement in open slots. Each coil consists of number of rectangular copper strips. The slot portion of the coil is pressed to close limits and the complete treatment ensures that the coil is fully thermoset and dimensionally stable. In order to have mechanical rigidity under short circuit conditions, the winding overhang shall be properly braced. The stator winding insulation system shall employ Vacuum Pressure Impregnation (VPI) technology to ensure enhanced protection against moisture ingress and environmental contaminants, as well as improved thermal dissipation while maintaining the required high dielectric strength. The VPI insulation shall be uniform along the entire length of the stator bar, including its slot (straight) portion and the bend portion, extending up to the brazing end, where only a suitable length shall be left uninsulated to accommodate brazing connections. The Jumper connectors and bus rings will also employ VPI. The winding shall be so designed to minimize the total harmonic distortion in the generator voltage.

The frame must be proportioned for the laminations and windings will be supported with practically no deviation from a perfect circle. The stator shall be designed to provide ready accessibility to the windings. Handrails shall be provided wherever necessary.

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The stator frame is to be designed for high torsional, buckling and vibration stiffness and fabricated construction built in multiple segments and assembled together on site for ease of transport. The stator frame rests on sole plates embedded in the concrete foundation.

The stator frame must allow a good positioning of the magnetic core laminations and support the weight of the magnetic core, of the winding of the upper bracket.

The stator frame must transmit the vertical loads, the normal and accidental torques and the radial forces to the foundations.

Some arrangement to be provided for inspection of overhang portion backside area.

The frame must withstand without excessive distortion, the centripetal and unidirectional magnetic attraction forces, which may result from accidental eccentricity of the rotor and shall not impose excessive stress upon the magnetic core, when the rotor expands with respect to the frame.

The stator frame assembly must be a firm assembly along with its magnetic core to prevent the electromagnetic forces due to the sub harmonics of the armature reaction wave from producing vibrations on load exceeding a reasonable level and it shall guide the cooling air towards the heat exchangers. It shall support the upper bracket and the connections and terminals and allow stator handling.

The stator frame is to be a fabricated structure and designed and dimensioned to withstand all possible stresses. Steel plate stiffeners are to be welded evenly distributed around the stator frame circumference, in such a manner to provide a stiff connection against eccentric displacement movements. These stiffeners shall be totally maintenance free and no regular inspection of the connection frame to base shall be required. Uniform guidance of the cooling air is to be achieved by streamlined sections and passages.

5.5.2 Generator stator sole plates

The generator frame shall be supported by sole plates that are embedded in the secondary concrete. The bidder shall supply sole plates including the anchoring bolts and the accessories for levelling up sole plates and any special grout mixtures required for grouting sole plates or can confirm the names of special grouts along with quantity require for each machine.

The sole plates are to designed to transmit the stresses to the concrete under the worst conditions (short-circuit, out of phase synchronizing).

5.5.3 Stator core

The stator core is built up with thin low loss insulated electrical sheet segments. It shall be stacked at site or factory. The active part of stator core is to be formed of low carbon, silicon alloyed lamination having a thickness of 0.5 mm with a very low loss factor and high-grade permeability. The laminations are to be punched in segments with winding bar slots, key bar slots and stud bolt holes. After the punching process and laminations are deburred and coat to be insulated on both sides with class F varnish. To achieve radial air ducts the stator core is divided into axial pockets of laminations. The cooling air ducts are formed by spacers. The shape and distribution of the spacers are chosen to secure uniform transfer of pressure as well as smooth flow of the ventilation air.

The overlapping segments are to be guided by double wedge shaped key bars. The key bars are to be positioned accurately on the inner bore of the frame to very close tolerances and are to be fixed in their final position at the frame ribs by using fixing plates welded to the stator frame. This type of connection between the stator core and stator frame shall ensure that the bore tolerance is observed up to the largest diameters. It also shall permit a clearly defined transfer of the operation torque and other forces to the stator frame and from there to the foundation. The laminations are to be compressed at both ends to prevent vibration of the teeth in operation. On completion of the pressing operation the applied pressure is to be taken up by pre stressed clamping bolts through the core.

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The pre stress of clamping bolts provided by hydraulic jacks and is calculated so that even when the core settles because of temperature and vibration, the pre stress shall be maintained. Clamping finger transfer the pressure to the stator core teeth.

The clamping bolts shall be located along the midline of the stator segments to ensures a uniform distribution of the core pressure. Additional spring elements in the clamping bolts shall ensure that the compressive force exerted on the laminations due to the prestressing of the bolts remains present even after a long service period of the generators. With this system buckling of the core is to be avoided.

The clamping system using "through bolts shall have clamping bolt, round nut and washer, insulating tube and thrust washer and Belleville washer, press plate and clamping finger.

5.5.4 Rotor

The rotor shall be of salient pole construction. The rotor shaft shall be of best quality carbon alloy steel. The poles shall be assembled from laminated steel sheets. The pole shall have dovetail to fit in a matching dovetail slot accurately machined on the spider. The pole along with field coil shall be properly secured in the dovetail slots and wedged there properly. (screwed wedge).

The rotor shaft and rotor itself shall be designed to withstand all the operating as well as runaway speeds. The rotor shaft shall have ample strength and stiffness to withstand stresses due to short circuits and other forces.

The rotor assembly shall be of such design that the assembling and dismantling can easily be affected at site. Poles shall be removable without removing the rotor from stator. Poles shall be removable from the shaft without disturbing the adjustment or setting of the guide and thrust bearings.

The rim of the rotor shall be constructed out of laminated sheet steel having radial ventilating ducts located along the lengths & bolted together to make a compact structure. The hub of the rotor shall be securely attached to the main shaft taking care of requirements both at normal operating speed and at maximum runaway speed conditions. The rotor spider shall be of fabricated construction with arms radiating from the central hub. The field winding insulation shall be of class F insulation with temperature rise limited to class B insulation (130oC).

5.5.5 Damper Winding

A low resistance damper winding of copper shall be provided on all the poles near the upper surface of the pole shoes to dampen rotor oscillations when a sudden load change occurs. It shall also help for satisfactory parallel operation and stability of the generators. They shall be short circuited at the ends by a completely connected ring on either side. The damper windings shall be strong enough to withstand all the electrical and mechanical stresses occurring during operation.

Top and bottom damper bars of the poles shall be shorted. The design shall be adopted such that no heating of pole ends shall be there when the generator is running both in leading and lagging power factor range during generator operation.

5.5.6 Poles and Field Winding

The pole shall be interchangeable and capable of repeated removal and replacement without loss of fit. Pole shall be removable without removing the rotor from stator. All field winding connections from pole to pole shall be located on the Non-Drive End side. These inter-pole connections shall use a bolted system and shall not be insulated, allowing for easy removal of poles during maintenance activities.

In order to facilitate inter change of connections to slip rings periodically to avoid undue wear of the slip rings due to electro chemical action, long studs shall be provided for brush holders assembly which can be moved up and down to achieve change of polarity of slip rings.

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5.5.7 Collector rings and brushes

The collector rings shall be insulated from the shaft system by epoxy glass laminations and spaced sufficiently apart and the brushes arrange to eliminate the possibility of accidental short circuit while changing or adjusting the brushes. The brush gear for the collector shall be mounted on insulated studs from the top of the exciter brush gear housing. The brake/slip ring housing shall have sufficient space for maintenance purposes

Carbon dust collection system shall be provided to extract carbon dust generated from the carbon brushes and convey it to the Carbon Dust Collector. In the collector, the dust shall be trapped by high efficiency, washable metallic filters, where it will accumulate and can be manually removed. The piping of carbon dust system shall comprise of PVC pipes and flexible hoses. If metal pipes are used, they shall be coupled with Straub coupling in order to facilitate quick dismantling and erection. The pipes should be routed in a way to optimize spaces.

5.5.8 Shaft

The shaft shall be of highest quality steel and sufficiently rigid so that it shall not vibrate or whip. It shall have an ample margin of strength and be provided with a forged coupling to the turbine. The coupling bolts shall be provided by the generator contractor. The supplier of the alternator must cooperate with manufacturer of turbine and agree as to what parts are to be supplied by each party where any doubt exists. The design of the coupling as already stated shall be worked out by the generator manufacturer in consultation with the supplier of the turbine. The Generator shaft shall be made of high-quality manganese steel, properly heat treated and shall be accurately machined all over and polished at the bearing surfaces and at accessible points for alignment checks. Generator shall be directly mounted on the turbine shaft. The design of coupling arrangements between turbine shaft and generator, and between runner and turbine shaft shall be based on bidders proven practice which shall be supported by the detailed calculation. The shaft shall have ample strength and stiffness at all speeds including maximum runaway speed to resist vibration or twisting on short circuit. The shaft shall be earthed through a brush gear assembly to avoid eddy currents flowing through the shaft.

5.5.9 Generator Housing

RCC generator barrel will be provided for housing the generator.

The generator barrel shall be designed as an airtight enclosure from the outside, so that the noise level at outside of the barrel is less then 90db and to prevent the ingress of moisture, dust, and foreign particles, thereby ensuring a clean and controlled internal environment for the generator components.

Provisions shall be incorporated within the barrel structure for the following:

i) Cable and pipe entry/exit points, which shall be equipped with sealed glands or airtight entry systems. These shall ensure leak-free operation while allowing safe and accessible routing of stator winding leads, instrumentation cables, auxiliary power and control cables, as well as cooling water and firefighting pipelines.

ii) Barrel access doors, which shall be lockable and fitted with high-quality gasket seals. Doors shall be provided with inspection windows and shall maintain the barrel's airtightness when closed and secured

5.5.10 Insulation

The generator stator and rotor winding insulation shall be class-F and the temperature rise shall be limited and guaranteed to that of class-B insulation while running at rated and overload conditions. (Stator winding with vacuum impregnated insulations)

The insulation shall be non-hygroscopic and shall be given tropical and fungicidal treatment for the satisfactory operation in hot, humid and tropical climate.

The Bidder must give a full description of the windings offered, both as to conductor and insulation large scale drawings shall be submitted showings the arrangement of conductors and

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the thickness and nature of all materials used both for insulation and mechanical protection in the slots of the stator.

Insulation shall be provided follows:

i) Stator winding thermosetting epoxy resin-mica paper tape system corresponding to class F insulation.

ii) Rotor winding thermosetting type most suitable insulation material, corresponding to class F.

With cooling air entering the generator at 40 °C (Cooling water temperature 30 °C) the generator shall be capable of delivering rated output continuously at any voltage and frequency in operation range, rated power factor without exceeding the excess temperature limits admissible according to IEC 60034-1 or latest additions, insulation category B, for stator and rotor windings.

Maximum temperature rises when the unit is delivering its maximum output and rate P.F. at any voltage and frequency in the range without exceeding the following temperature rise over cold air temperature of 40 °C should be as per class B limits as per IEC.

The temperature of the stator winding shall be determined by means embedded resistance type temperature detectors located in the stator winding between coils at the center of the core. The temperature of the field shall be determined by the resistance method.

The winding must be capable of being easily substituted by removing a few adjacent coils. The projecting parts of the coils must be suitably braced and supported by rings of no-magnetic material to withstand any movement caused by short circuit at the terminals of the machined in grounded or underground operation. Necessary tool and tackles shall be provided for removal and insertion of coils.

All the six stator terminals shall be brought out into a vermin proof terminal box which shall accommodate the cables and connecting links for the alternator windings.

The stator winding and core design shall be such that there should be sufficient space at the winding back side for the replacement of coils or repairs to the stator winding.

5.5.11 Embedded Temperature Detectors (ETDs)

Duplex RTDs for measurement of temperatures should be embedded in the core and wired to temperature gauge panel with shielded cables.

Duplex type Resistance temperature detectors (RTD s) shall be arranged symmetrically in the stator winding to indicate/monitor the highest temperature obtained during operation. The temperature detectors are to be installed between the upper and the lower layer of the same phase. They are to be distributed symmetrically in the winding over all three phases. Resistance type temperature detectors are to be arranged to the outside of the stator core to facilitate temperature monitoring.

A suitable terminal board shall be mounted on the Generator frame to terminate the RTD resistor element connections. The temperature detectors lead shall be flexible as far as possible to facilitate dismantling without breakage. The necessary wiring between the terminal board and the individual temperature detectors shall be supplied with the Generator. Number of resistance type detectors shall be indicated in the tender.

5.5.12 Bearings

Generators shall be provided with thrust/guide bearing (depending upon type of coupling) on DE side and guide bearing on NDE side. Bearings shall be designed to take the required axial / radial load and constructed for easy maintenance and dismantling. A suitable screw mechanism shall be provided to allow easy adjustment of the gap between the guide bearings and the shaft journals.

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The bearing system shall be complete with all the auxiliary devices / equipment including lubrication system.

Bearings shall be oil lubricated type for uniform load distribution among stationary bearing pads and equalization of oil film pressure on sliding surfaces.

BIDDER shall indicate the requirement of oil and specification of indigenous oil required for the bearing and conform its suitability. The oil required for the first filling along with 10% extra oil in non-returnable drum shall be supplied by the CONTRACTOR.

Each bearing shall be provided with dial type thermometers having two separates 'NO' contacts, each of adequate rating for alarm and trip.

At each bearing provided with RTDs, dial type thermometers, etc. as listed in the “LIST OF INDICATING DEVICES” (BIDDER to confirm adequacy) for indication/recording and alarm as well as for tripping the unit in case of high temperature.

The guaranteed operating temperature of the bearing at rated output and overload condition shall be indicated. However, the bearing pad temperature for ‘alarm’ and ‘unit trip’ shall not be higher than the value indicated in the datasheet.

The Bearings shall be designed to withstand maximum runaway speed for period of 30 minutes without undue temperature rise and without supply of cooling water.

The NDE bearing shall be insulated to prevent any harmful circulating current from passing through bearing surfaces.

5.5.13 Space Heater

Space heaters of adequate rating shall be provided for maintaining stator surrounding air temperature above the ambient during prolonged shut down period. Thermostat shall be provided to trip the space heater supply if the inside temperature of the generator rises above the pre-set value.

The space heaters shall be placed in easily accessible positions in the lower part of the generator frame and shall be protected by guard.

5.5.14 High Pressure Oil Lubrication System

H.P. Lubrication system, A high pressure oil system should be provided for the thrust bearing to create a positive oil film over the pads at low speeds during starting and stopping of the generator. The components consist of a positive displacement pump with its motor, filters, and valves etc., mounted on a steel base. A pressure gauge, pressure switches (each for AC and DC motors) with electrical contacts for starting interlock of the generator shall also be provided. The system shall be arranged to come into operation automatically during starting/stopping and when the generator starts creeping. The duplicate oil pump sets one may be suitable for A.C. 3 phase, 415V 50 Hz, drive for normal service and the other suitable for D.C. 220V, drive from the station battery for emergency lubrication if the A.C. power fails. The switchgear required for control and operation of these motors shall be included in the tender. The equipment shall be provided with an automatic arrangement by which in case of failure of A.C. supply the set shall be switched on to D.C. The analog value of pressure is to be made available on HMI.

5.5.15 Oil’s

The bidders shall indicate this requirement and give his recommendations with detailed specifications regarding type of oil to be used for lubrication of generator bearings. The oil if used for generator bearing lubrication etc., shall be identical with that used for the pressure oil system of governor. The generators and turbine manufacturers shall cooperate to ensure that their recommendations regarding oil are identical. The first filling of oil with 10 percent extra shall be supplied along with the generator. The oil must be commonly available in India.

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5.5.16 Oil & Air Piping

Oil and air piping inside the generator barrel shall be carried with Union joints for ease of maintenance and dismantling if necessary. Pipes shall be routed with suitable and robust clamps at regular intervals with necessary markings for identification.

5.5.17 Piping

All air and oil piping systems within the generator air housing valves and fittings shall be designed and connections to them brought to position adjacent to housing at the side of the Generator as required by the purchaser to be supplied by the contractor. Valves and other operating devices shall be easily accessible from floors or walk – ways.

All Cooling water pipelines inside and outside the Generator barrel shall be of Stainless Steel piping with anti-condensation coating.

Sight flow device shall be furnished in the bearing oil supply and return and also in the bearing cooling water return

The arrangement of piping and location of valves etc., shall lead to minimum disturbance when generator is dismantled, or parts removed for inspection and repairs.

All pipe systems associated with the generator such as oil flow, air flow and cooling water shall be supplied in semi-fabricated condition with an extra length of 10% to cover any possible shortages.

All embedded pipes shall be seamless pipes of thickness of next higher rating than specified as per the IS standards for that requirement and application or minimum of 10 mm thick. All Valves used for water system used in the powerhouse area must be of stainless-steel valves with raising stem only.

All pipes used inside generator barrel for water shall be of stainless steel to avoid corrosion and failure /puncture during operation. Also, the expansion joints should be of SS bellows.

5.5.18 Brakes and Jacks

Each Generator shall be provided with a set of compressed air operated mechanical brake, One Vacuum cleaner along with required babbles etc. to remove the braking dust from the stator winding and oil- operated jacks including pipes and valves inside the generator. For stopping the generating units quickly, each generator shall be provided with compressed air operated brakes which shall be operated automatically and manually. The generator brake would consist of a suitable number of brake shoes which shall operate against a polished segmental steel brake track bolted to rotor. Compressed air at required pressure shall be made available from the Low pressure compressed air system. Two compressors of suitable capacity with accumulator tank and with necessary valves and pressure switches and control panels shall be supplied. When Brakes are operated, the Unit shall be capable of bringing the entire generating unit from 30 % of rated speed to rest within 5 minutes without injurious heating. When acting as a jack, the set shall be capable of lifting the combined weights of all rotating parts of the generator and turbine sufficiently to facilitate easy inspection ad removal of bearing parts. Mechanical blocks attached to the jacks shall be provided to hold the rotor in the raised position. An interlock shall be arranged so that the unit cannot be started with brakes or jacks in position and for prevention of application of brakes when the speed is above the safe limit for application of brakes. The safe limit for application of brakes shall be stated by the bidder. Complete set of arrangements including valves, gauges, piping etc. shall be provided for each individual Units. Brake indications should be provided on the HMI.

The BIDDER shall furnish a full description of the brake and jack system and its installation detail for the unit. The BIDDER shall also list all devices/equipment viz. indicators, limit switches, interlock, indications and annunciators for the brake and jack system adopted for this unit. Requirement of compressed air and its pressure shall also be indicated.

Motorized hydraulic power pack along with necessary starters, valves, gauges safety valves/Recirculation valves etc., shall be provided for jacking the rotor of each unit during

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maintenance. Flexible hoses with swivel nuts for connection between power pack and brake jack control panel shall also be provided.

Brake dust collection system shall be provided for brake dust collection system to suck brake dust generated during braking action. The filters used shall be metallic and washable type having high efficiency. The piping of brake dust system shall comprise of PVC pipes and flexible hoses. If metal pipes are used, they shall be coupled with Straub coupling to facilitate quick dismantling and erection. The pipes should be routed in a way to optimize spaces.

5.5.19 Elimination of Oil Mist Emissions

The first principle to prevent oil mist emission from a bearing is to prevent air from entering the bearing housing. To achieve this, as the clearance between rotating parts and bearing covers cannot be reduced to zero, all other entry points such as vents and pumping holes must be closed. In this way, the circulation of air and subsequent production of oil mist is minimized. In the area of upper and bottom covers, a double chamber labyrinth seal is to be used which shall be pressurized around the shaft/collar above and below the bearing. The external chambers of the labyrinth seals are connected by means of pipes to the end winding covers or to the outside of the generator housing to balance pressure between the upper part and the lower part of the bearing and to provide clean air in these chambers. The internal chambers are to be connected by means of pipes to an oil mist treatment apparatus. This apparatus is provided with an air fan which sucks air from these pipes and from a pipe connected to outside to ensure the rated flow of the apparatus. This pipe is provided with a valve to adjust the suction effect.

5.5.20 Mechanical & Hydraulic Over Speed Devices

The Bidder shall provide both mechanical and hydraulic over speed devices with provisions for electrical and mechanical tripping, on the top of Turbine/Generator shaft of each unit above the topmost bearing of the unit.

The mechanical and -hydraulic over speed devices shall be of suitable well proven modern design mounted on the top of the upper shaft extension and consist of spring-operated latched mechanism. The switch shall be tripped by a spring-loaded plunger carried on the extended shaft. The switch box shall be shorted when the plunger hits the cam of the switch box. The device can be reset by hand and shall have a suitable range of adjustment. The over speed device shall be set to trip at a speed above the full load throw off speed of the unit. These mechanical and hydraulic over speed protection devices shall be directly connected to the Turbine/Generator shaft, to initiate the shutdown at excessive over speed. These trip devices shall be independent from normal governor action.

The mechanical and hydraulic tripping device shall directly actuate the governor shut down valve though a hydraulic connection, whereas the mechanical tripping device shall actuate a switch that triggers the emergency action shutdown from the Unit Control Board, in case of unit speed exceeding present limit. It shall be furnished complete with rotating and stationary trip mechanism, guards, connection to inlet valve control, and necessary supports. The device shall meet the following requirements.

The mechanism shall be completely mechanical and hydraulic, and not dependent on speed sensors for its operation. However, two electrical independent ungrounded change over contacts shall be provided for alarm and initiating governor shutdown.

An electrical over speed protection shall be included in the scope of supply and its details shall be indicated in the bid.

5.5.21 Speed Sensing Device

A suitable arrangement is to be made on the shaft of the unit and two photo interruptive pickup/ proximity sensors must be mounted on a bracket to pick up the speed of the shaft.

The speed signal of the unit through a special screened cable shall provide signal to the Governor Control Board / Unit control through suitable transducer at a frequency directly related to the speed of the set.

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A backup speed relay cum speed monitor for Generator to measure the speed with adequate number of auxiliary (NO & NC) contacts at required steps shall be provided.

Speed sensing through PT voltage is to be provided in addition to the speed sensor. Also consider speed indication from the generator frequency signal.

5.5.22 Monitoring Sub-Systems

Following On-Line monitoring sub-systems shall be provided:

i) Necessary arrangement for on-line Vibration monitoring of Turbine & Generator

ii) Necessary arrangement for Air Gap of Generator units

iii) On-line Partial Discharge Monitoring system for Generator

iv) Shaft Current online Monitoring of Generator

v) Online Temperature Monitoring of Generator for Core, winding, Air, Water, & Cooling

For technical requirements of instruments refer I&C Chapter 61.

5.6 Partial Discharge

A stator winding partial discharge measurement/analysis (PDA) system shall be provided for each generator based on the capacitive coupling measuring principle to detect undue discharge currents. A minimum number of Nine (9) pick-ups shall be distributed evenly at the winding overhang perimeter. The measuring signals shall be filtered and evaluated via signal multiplexer through two common portable data acquisition and monitoring unit assigned for all generators.

Each Unit has 9 sensor couplers having suitable coupling capacity and one Portable type of PDA for all units. There shall be a provision to integrate this system information into DATA ACQUISITION & DATA ANALYTICS SYSTEM with provision for analysis of data.

PD detection shall be based on electrical pulse sensing by means of sensor capacitors installed for the purpose. Three (3) capacitors one on each phase and connected between phase and earth at the line end shall be provided. Additionally, one (1) capacitor shall be provided across the primary winding of neutral earthing transformer. The leads from all the four (4) capacitors shall be terminated in a terminal box. A digitizing unit shall be provided to receive signals from the terminal box.

Similar arrangement shall be made for each generator in a multi generator station. A common evaluation unit shall be provided to acquire signals from each of the digitizing units, where they are analyzed and displayed. A color laser printer shall form part of the evaluation station. The distance between the Generators shall be around 25m. The medium of the communication shall be selected appropriately.

All the Resistance temperature detectors (RTDs) provided for measurement of temperature of stator coils shall be used, in conjunction with coupling capacitors, to capture signals pertaining to PD activity. Slot couplers may also be provided and used instead of RTDs, depending upon manufacturing practices in respect of generators. Redundant slot couplers shall be provided.

The cables from sensors to the digitizing unit shall be shielded to prevent true PD signals from being corrupted by external noise. Each lead shall be provided with a suitably rated surge arrestor before being terminated at the digitizing unit. The digitizing units of several generators and the common evaluating station shall be linked preferably by fiber optic cables.

The sensing capacitors shall have same dielectric withstand capability as the stator winding. The frequency response shall be in the range of 30 kHz to 2MHz.

The digitizing units shall be fitted with noise rejection filters to minimize the effect of series mode and common mode noise injected into the PD detection system from external sources.

The sensors used for detection of PD, digitizing units, processing of digital signals, their presentation and evaluation shall all be in accordance with IEC 60270 and IEC 60034-27-2.

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The display unit shall be capable of presenting PD activity in vivid color graphic displays. It shall have enough storage capacity to generate trend displays.

The PD detection system shall include a suitable calibrator and both the measuring system, and the calibrator shall comply with the type and routine tests mentioned in IEC 60270.

The system shall be designed to operate on 230V±10% 50Hz AC supply.

5.7 Shaft Current

A low-voltage ring type current transformer in a parted form of construction shall be used for measurement of shaft current. It is to be designed for installation at the bearing shield, around the generator shaft. Thus, the shaft current relay shall detect the transient current of the generator shaft.

Maintenance-free low-voltage current transformers for indoor application with high quality cast resin insulation complying with international standards (IEC 60044-1/-6, VOE 0414, DIN 42600, ANSI, GOST) shall be used. The GWR type are used for indoor application.

The shaft current transformer shall be designed and adjusted for faultless operation together with a shaft current relay, shaft currents smaller than 0.5A can be detected and system is to be connected to alarm.

There shall be a provision to integrate this system information into DATA ACQUISITION & DATA ANALYTICS SYSTEM with provision for analysis of data.

5.7.1 Creep Detector Equipment.

Creep detector equipment shall be provided to detect creeping of the generator at very low speed. It shall give alarm as well as initiate the hydrostatic lubrication system and braking system simultaneously. (to be incorporated in the Unit Control logics)

5.8 Gauges

Each generator shall be provided with the following instruments and gauges.

Oil level gauge and Transmitter with indication & programmable switches for guide and thrust bearings and oil reservoir should be mounted in an accessible position.

Normal level, High- and low-level alarm and trip contacts for guide and thrust bearing oil reservoir.

Remote gas type temperature indicators with D.C. alarm and trip contacts both for guide and thrust bearing shoes.

Cooling water flow indicators and Transmitter with indication & programmable switches for generator air coolers, bearing with alarm contacts. CW flow to be configured on HMI.

5.9 Terminal Box

The phase terminal of the windings shall be brought out of stator frame through insulated bus bars of adequate size & capacity of class F insulation. The leads on the neutral side shall be brought out of the stator frame and shorted through a suitable size bus bar. Provision shall be made on the main (Phase) side & neutral side of the Generator for mounting of required no of CTs for AVR, control, protection & metering.

Separate terminal boxes shall be provided for each of the following.

i) Instrumentations Terminal Box.

ii) Space heaters Terminal Box

iii) Temperature detectors Terminal Box.

Terminal boxes shall be of weatherproof construction to eliminate entry of dust, vermin and water with a degree of protection IP-54. The terminal boxes on the generator shall be suitable to connect cable size required.

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The phase and neutral terminals shall be of phase segregated type suitable for IPBD termination, and the arrangement shall be suitable for short circuit capacity as specified.

5.10 Ventilation & Cooling

Closed circuit air ventilation system shall be provided for removal of heat and control of temperature of stator and rotor winding and machine enclosure. The air shall be circulated by using shaft-mounted fans. The air in turn shall be cooled by circulating water heat exchangers.

Axial flow centrifugal / suitable arrangement shall be provided at the rotor for ventilation/cooling purposes.

The system of the ventilation shall be of the self-contained closed circuit with water cooling arrangement.

Enough surface air coolers shall be provided, located symmetrically around the stator frame to cool the air from the generator. A valve shall be provided in each connection between cooler and water headers of inlet & outlet.

The tubes of the surface air cooler shall be of Cu-Ni material. Each cooler shall have flanged connections at the bottom, which shall completely drain the cooler and shall have air vents at the top; each air vent shall be connected through a valve to a common header and vented to the water supply line. The entire water system shall be designed to prevent accumulation of sediment with water flow reversal arrangement provisions. Lifting lugs shall be provided to remove any cooler through the top of the generator housing. Water boxes shall be removable for cleaning tubes. The pipe work shall terminate in flanges for connection to external pipe and these flanges shall be as per standards for pipe flanges ASME/ANSI B16.5 / EN 1092.

The flow relays with indication and Transmitters with local indication shall be provided in the main header of all cooling water circuits of Generator.

A drainage system with valves at each cooler shall also be provided for draining the coolers in case of maintenance.

Cooling water supply shall be from closed loop header pipeline. All valves, water flow indicators, transmitters and alarm relay contacts shall be provided. The pipe work shall terminate in two flanges (supply and outlet) for connection to external pipe work shall be made.

Generator shall be provided with air coolers fixed to the stator frame for dissipating the heat in the generator stator and rotor, in closed circuit coolant/air circulation. This system shall be complete with air coolers, cooling fins, fans, cooling water pipes, valves, ducts, filters/strainers, sealing plate, alarm and indicating devices, flow relays, RTDs etc.

The BIDDER shall indicate the type of cooling system he proposes for the unit as per his design standards.

The design of the cooling system shall be such that one cooler can be taken out of service without the generator exceeding the permissible temperature rise while delivering rated output at rated conditions.

All water piping including ring headers, connecting pipe from the cooling header, control valve near each cooler etc. shall be provided by the BIDDER.

Adequate number of RTDs shall be provided for indication/recording/alarm and unit trip.

Pressure gauges with low pressure contact for the inlet and outlet cooling water to air coolers, flow relay-cum-indicator for water in the common discharge pipe of air coolers, for water outlet in each air coolers shall be provided. Cooling water pumps with A.C. motor of adequate capacity to meet the full requirement of cooling water for bearing oil coolers and generator air coolers etc. shall be provided. One pump shall be normally working and other standby. The BIDDER shall furnish full details of devices / equipment / controls / indications / annunciators proposed for the cooling system.

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5.11 Oil Coolers

This system shall be complete with oil coolers, fins, cooling water pipes, valves, strainers, alarm and indicating devices. Flow relays, RTDs / thermocouple etc. shall also be included. RTDs / thermocouple shall be provided for indication/recording of the common cooling water outlet temperature of bearings. Pressure gauges with low pressure contact shall be provided at cooling water inlet and outlet to/from thrust and guide bearing oil coolers and flow relay cum indicator shall be provided in the water discharge pipe of thrust and guide bearing oil coolers. The bearing oil cooling system shall consist of oil and cooling water heat exchangers installed externally to the generator barrel to facilitate easy maintenance and effective heat dissipation. The oil for the thrust and guide bearings shall be self-circulated by the action of the rotating generator shaft, eliminating the need for external oil pumps. The heat exchangers shall efficiently transfer heat from the bearing oil to a closed-loop cooling water system, maintaining oil temperature within the manufacturer's specified limits under all operating conditions.

All water piping, including ring header, connections, pipe for the cooling header, control valve near each cooler etc. shall be provided.

5.12 Control Protection & Monitoring

Necessary controls indications, meters, disturbance recorders & annunciations as required & detailed elsewhere for satisfactory operation of the unit shall be included in the scope. Required PLC/SCADA shall also be offered for the control and monitoring of the generator units and its auxiliaries. Required Transducers, auxiliary contacts, sensors, IPRs shall be provided to implement PLC/SCADA system.

The facility for installing all performance monitoring devices as required by the PLC/DCS shall be provided. The VENDOR shall fully coordinate and cooperate with the PLC/DCS supplier in the supply, installation and commissioning of the interface system. Typical hydro electric generator performance monitoring charts shall be provided. The required number of output shall be made available for the remote annunciation system in Generator control panel and PLC/DCS (as applicable).

5.13 Rating Plates

Suitable base frame/sole plate for resting the generator/bearings on foundations shall be provided depending on the type of generator construction. The PURCHASER will provide concrete foundations as per requirements of the generator manufacturer. All the embedded parts, dowels, foundation bolts, nuts, template for foundation etc. along with the detailed drawings shall, however, be supplied by the BIDDER.

5.14 Drain Plugs

Drain plugs shall be provided in the generator casing & it shall be so located that it would be possible to drain from all pockets water or any other liquid entered the generator casing.

A water detection system is to be provided to monitor water leakage in the generator barrel.

5.15 Fire Detection & Protection System

Fire detection and protection system shall be provided for the generator.

Environment friendly Inert Gas based fire extinguishing system common to all Generators with redundant cylinder bank along with smoke and heat detectors as per NFPA guidelines

Bidder shall furnish details of the fire detection and protection system if alternative or additional system is proposed other than the above indicated system.

Door-fan test shall be conducted to prove the air tightness of the Generator barrel to ensure effectiveness of fire protection system.

All the alarms are to be made available on the remote HMI (control room).

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5.16 Performance Guarantee

5.16.1 Guaranteed Output

The rated output at 167MVA at rated power factor of 0.9 and at any voltage and frequency in the specific operating range without exceeding the maximum permissible temperature limits shall be guaranteed by the Bidder

5.16.2 Guaranteed Efficiency

The guaranteed weighted average efficiency at the design head shall not be less than 98 percent and shall be calculated as follows:

$\eta_{aw} = 0.18 \times \eta_{110} + 0.31 \times \eta_{100} + 0.26 \times \eta_{75} + 0.25 \times \eta_{50}$ where,

η_{aw} = Weighted average efficiency

η_{110} = Efficiency at 110 percent of rated (167) MVA and 0.90 p.f

η_{100} = Efficiency at 100 percent of rated (167) MVA and 0.90 p.f

η_{75} = Efficiency at 75 percent of rated (167) MVA and 0.90 p.f

η_{50} = Efficiency at 50 percent of rated (167) MVA and 0.90 p.f

Liquidated damages shall be imposed as per Clause 1.5.6, "Liquidated damages for shortfall in output and efficiency" in case of shortfall in weighted average efficiency/output vis-à-vis the corresponding guaranteed value.

The liquidated damages on account of shortfall in weighted average efficiency shall be computed separately for each unit and the total amount of liquidated damages shall be the sum of all the units.

However, tolerance in computation of efficiency (as per IEC 60034-1) shall be in accordance with the IEC 60034-1 for field acceptance test for generators.

5.16.3 Liquated damages for shortfall of output and efficiency.

For any shortfall in the tested values of rated output and the weighted average efficiency of generator vis-à-vis the corresponding guaranteed values respectively, shall be computed as follows:

(A) Output

For each of one hundredth of one (1) percent (0.01%) shortfall in tested value of rated output vis-à-vis corresponding guaranteed value	Equivalent to **INR/NU 13.09 Million**

(B) Weighted average efficiency

In weighted average efficiency each one hundredth of percent of the guaranteed value for each generator	Equivalent to **INR/NU 13.09 Million**

For fractional values of shortfalls in percentage, the liquidated damages amount will be computed on pro-rata basis.

The liquidated damages on account of shortfall of output and weighted average efficiency shall be computed separately. The total amount of liquidated damages shall be the sum of these two multiplied by number of generators.

However, tolerance in computation of efficiency (as per IEC 60034-1) shall be in accordance with the IEC 60034-1 for field acceptance test for generators.

5.16.4 Rejection Limit for Short in Output and Efficiency

The Employer reserves the right to reject the generator if the tested values of either weighted average efficiency or the rated output of 150 MW @ generator terminals, at design head of

761.5 m falls short by one (1) percent or more of the corresponding guaranteed values during field acceptance tests.

5.16.5 Tender Evaluation on Account of Efficiency Differences

For the purpose of comparison of bid, the quoted prices shall be enhanced by capitalization for the shortfall in efficiency and output at the rate of Nu/Rs.13,090,000.00 (Thirteen million Ninety Thousand) per one hundredth of 1% (0.01%) difference to the highest value quoted by any one of the bidders. Loading for all the four generators shall be considered for equalization. No change in the values of efficiency/output Quoted in guaranteed & technical particulars shall be permitted after opening of bids & evaluation will be carried out on the basis of information furnished by the bidder in the bid.

5.17 Test

The tests shall be in accordance with the applicable requirements of the IEEE 115 "Test procedure for Synchronous machines". The supplier shall intimate the testing program sufficiently in advance, so that the tests may be witnessed by the Owner or his authorized representative. The witnessing of the tests by the Owner or his representative (s) shall not relieve the manufacturer of his responsibility to fully meet the requirements of these specification and the guarantees.

Type test certificates for tests conducted on Generators of similar design and rating not lesser than tender requirement conducted within the last 5 years shall be furnished.

Advance copies of the test certificates shall be sent to the Owner for approval. The equipment shall not be dispatched until the Owner's approval in writing for the test certificates is obtained.

Routine tests – Factory tests on hydro generator are generally limited to tests on generator components; not assembled machines.

Factory tests for this application would be:

i) Stator Frame dimension checks and NDT of frame welds

ii) Stator Winding Bars Dimension Checks, Strand insulation tests, HV withstand tests, Slot Semi-conducting section coating resistance measurement, and Partial discharge measurement. On selected sample bars further tests would include Tan Delta (in accordance with EN 50209), insulation breakdown strength tests.

iii) Type test report of voltage endurance and thermal cycling tests for similar voltage level shall be submitted.

iv) If the stator is fully assembled in Factory and then transported to site – other tests would be winding resistance measurement, insulation resistance/PI measurement, HV withstand on completed winding.

v) Pressure tests of the Stator Air/Water Coolers

vi) Rotor poles turn insulation tests and high voltage withstand tests.

5.17.1 Test at Site

The following Type Tests along with routine tests shall be carried out on any one Generator set of each type at site in accordance with IS 4722/1968 and IEEE 115 or relevant IEC or as per other relevant standards but not limited to the following:

i) Measurement of DC winding resistances of Stator &Rotor.

ii) Insulation of stator &Rotor windings Bearings& embedded Temperature Detectors.

iii) High voltage of Stator &Rotor.

iv) Phase sequence.

v) Determination of OCC&SCC for Determination of equivalent circuit parameters.

vi) Measurement of insulation resistance of stator, rotor &Excitation before and after HV test.

vii) Over speed test.

viii) Efficiency test-Determination of Efficiency by Separation of Losses Method.

ix) Determination of No-load losses.

x) Temperature rise test &measurement of I^2R losses.

xi) Impedance of Rotor winding.

xii) Dielectric tests before and after over speed tests on all equipment.

xiii) Measurement of Vibrations at all loads and Full load throw-off &over speed test.

xiv) Measurement of Air gap at all loads and Over speed.

xv) Measurement of Partial discharge.

xvi) Measurement of Shaft current.

xvii) Pressure test on coolers.

xviii) Voltage balance.

xix) Determination of deviation of voltage waveform from sinusoidal.

xx) Measurement of Harmonics (Current &voltage Harmonics &determination of THF) as per IEC.

xxi) Protection checks on Generator & Converter.

xxii) Checking of Protections.

xxiii) Checking of Alarms &Trip settings.

xxiv) No load and short circuit saturation curves.

xxv) Wave form: Oscillographs shall be taken of the armature winding when the Generator is operating at rated voltage.

xxvi) Resistance of Stator & Rotor windings (on all machines).

xxvii) Short circuit ratio.

xxviii) Phase sequence tests.

xxix) Line charging capability test.

5.17.2 Other Site Tests

The following tests shall be carried out for all Generator set at site in accordance with IS 4722/1968 and IEEE 115 or relevant IEC or as per other relevant standards but not limited to the following:

i) High voltage dielectric test on stator bars inserted at site.

ii) Measurement of DC winding resistances of Stator &Rotor.

iii) High voltage test on stator and rotor after assembly before lowering and after lowering into the pit

iv) High voltage test after spinning and before commissioning of the Generator.

v) Checking the alignment.

vi) Checking the braking and jacking system.

vii) Hydro static test on all Generator coolers and bearing coolers.

viii) Alignment of Generator rotor, and runner and shaft system.

ix) Rated current, zero power factor lagging and saturated current test.

x) Phase sequence test.

xi) Mechanical run for checking the mechanical balance, bearing temperature and effectiveness of braking system.

xii) Measurement of shaft voltage

xiii) Load acceptance and rejection test at selected loads from no load to full load

xiv) Overall response of machine and excitation system

xv) Synchronizing test

xvi) Checking and commissioning of various other auxiliary equipment.

xvii) Determination of time for stopping the machine with zero field current on application of brakes at 30% of normal operating speed with pump wicket gates in closed position. (Time-rpm deceleration curve).

xviii) Temperature rise test.

xix) Other miscellaneous tests:

a. Visual inspection and wiring check.
b. Insulation test voltage withstand test.
c. Checking of control and relay logic.
d. Excitation system frequency response (phase and gain) curves to be made on each Generator.
e. Overall response of machine and excitation system voltage changes.
f. Test of maximum over excitation system limiter.
g. Test of 'volts per cycle' - regulator.
h. Minimum under excitation limiter test.
i. Effectiveness of voltage regulator forcing action in demagnetizing of the main regulator field.
j. Tests to determine the field current under the following conditions.
    - Rated KVA, rated power factor and 110% voltage.

xx) Dielectric test for excitation transformer.

xxi) Adjustment of AVR.

xxii) Relay test.

xxiii) Shaft voltage.

xxiv) Phase sequence.

xxv) Automatic start and stop test.

xxvi) Synchronizing test.

xxvii) Quick and emergency stop test.

xxviii) Exciting current test: The exciting current test shall be performed at rated or near the rated voltage provided that the unit step-up transformer is able to withstand 50% exciting current for 15 seconds at rated voltage.

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5.17.3 Excitation System and Automatic Voltage Regulator

The tests to be conducted at works on the AVR shall include but not be limited to, those listed herein. Any other tests recommended by the BIDDER shall be specifically brought out in the tender.

i) Measurement of insulation resistance
ii) Performance test
iii) Performance test of all limiters and regulators
iv) Impulse input response test
v) High voltage test
vi) Tests for Auto-standby tracking the Auto-active channel and Auto-changeover
vii) Ranges of voltage adjustment test for both auto and manual channels
viii) Output test
ix) Functional checks on complete excitation system & automatic voltage regulator.
x) PSS trails to be conducted.

Copies of valid test certificates and records of tests shall be submitted to the PURCHASER for approval.

Bidder shall indicate the tests which cannot be conducted at factory and can be conducted only at site.

5.18 Pre-Commissioning & Commissioning Checks

Pre-commissioning and commissioning checks shall be carried out on the generator and all the other equipment supplied by him as per the commissioning check lists.

5.19 Installation Tolerances

Contractor shall provide a detailed alignment procedure clearly stating the clearances and tolerances that are to be achieved. The recommended erection tolerances and alignment shall be agreed with Engineer.

5.20 Installation Records

The contractor shall maintain the installation records including installation quality control (QC) records of each activity to ensure quality of installation as per specification / requirement. The QC records shall clearly show the achieved erection tolerances vis-à-vis the allowable limits. The installation records shall be submitted to the Employer for approval/acceptance. All installation records shall be compiled and submitted to the Employer before taking over the respective unit. Completion certificate for any work shall be issued only after approval/acceptance of complete installation records.

5.21 Tests during Installation

The contractor shall carry out all the dry tests during installation for the part / subassemblies where ever required to avoid repeated dismantling and reassembly of the parts/sub-assemblies viz., Motors, pumps, servomotors, level gauges, pressure gauges, flow meters, temperature detectors etc. due to their malfunction after erection, The contractor shall furnish a protocol of dry tests in along with the erection manual and submit to the Employer for advance information and train O&M staff.

5.22 Field Inspection

i) The Contractor shall permit the owner to perform inspection of the assembly which shall include a complete verification of the assembly of all parts as to their levels, clearances, pertinent fits, alignments and quality of workmanship. The field supervisor of the contractor shall provide the Employer with copies of all the clearances, tolerances and data of all pertinent fits, alignments and levels, some of the contractor measurements would have to be repeated, if so desired by the Employer.

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ii) Unless otherwise specified, any rejection based on the inspection will be reported to the contractor within fifteen (15) days and injurious defects subsequent to assembly and acceptance will be rejected.

5.23 Painting & Finish

i) Internal and external of the Generator casing and all metal parts shall be painted with two coats of epoxy paint that shall resist corrosion due to ambient conditions as per the color approved by the Purchaser. The Lubrication oil system shall be painted with relevant color code as per IEC. The color of external paint shall be as per the color approved by the Purchaser.

ii) Machined and finished surfaces shall be protected against formation of rust and corrosion by application of suitable rust inhibitors. All steel surfaces which are to be painted shall be thoroughly cleaned, degreased before being painted. All castings shall be sand blasted, degreased and cleaned before painting.

iii) Standard color codes shall be used for different pipelines like oil, water, gas, air, etc.

5.24 Deputation of Engineers for witness of Tests, Inspection & Training

The Employer's representatives shall be deputed for the following purposes.

Sl. No.	Description	Batch	No of Days	No. of Engineers and Technicians
1	Training at the plant and design office	2	5	4 Engineers 6 Technicians
2	Shop Inspection and Test	As and when required for inspection and test		

The training of employer's personnel shall be as specified in clause 11.0 "Training of Employer's Personnel" of General Technical Specification.

5.25 Spares & Special Tools

Bidder shall include the Start-up and Mandatory spares as listed under list of spares. The spares shall also include lifting lugs, wire ropes, hackles, turn buckles, eye bolt etc. for rotor treading at site. Detailed drawing for rotor treading arrangement shall be furnished.

All special tools and tackles required for the erection and maintenance of the Generator & accessories shall be included in Bidder's scope.

Bidder shall furnish a list of recommended spares and service support for satisfactory operation of the equipment for 15years.

5.26 Erection

All the equipment supplied by vendor shall be erected as per the certified / approved erection procedures.

5.27 List of Indicating Devices/Instrumentation for The Unit (Minimum requirements are listed below)

Sl. NO	Description	Device Type	Qty.	Location
1.	Dial thermometers for Generator bearing Temperature for local display for all the three Bearing (UGB, LGB, Thrust Bearing)	DTT	3 sets	Generator gauge/ local panel & Control Panels HMI
2.	RTD for Bearing lubricating oil for all the three Bearing (UGB, LGB,	RTD	3 sets	Generator gauge/ local panel & Control Panels HMI

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Sl. NO	Description	Device Type	Qty.	Location
	Thrust Bearing) for each oil tank			
3.	RTD for Bearing Metal Temperature for all the three Bearing (UGB, LGB, Thrust Bearing) for each pad	RTD	3 sets	Generator gauge/ local panel & Control Panels HMI
4.	Temperature detectors for stator winding temperature for each Phase	RTD	3 sets	Generator gauge/ local panel & Control Panels HMI
5.	Temperature detectors for stator core temperature	RTD	6 sets	Generator gauge/ local panel & Control Panels HMI
6.	Flow meters for Bearing cooling water	Flow Meter	3 sets	Generator gauge/ local panel & Control Panels HMI
7.	Flow for Bearing lubricating oil	Flow Meter & Flow switch	5 sets	Generator gauge/ local panel & Control Panels HMI
8.	Pressure for Bearing Cooling water of three bearings	Pressure Gauge & pressure transmitter	3 sets	Generator gauge/ local panel & Control Panels HMI
9.	Moisture detectors for each Oil sump	Moisture Detector	3 sets	Generator gauge/ local panel & Control Panels HMI
10.	Temperature of air cooler inlet air covering all Coolers of Unit	1 RTD in each cooler	1 set	Generator gauge/ local panel & Control Panels HMI
11.	Temperature of air cooler outlet air covering all Coolers of Unit	1 RTD in each alternate cooler	1 set	Generator gauge/ local panel & Control Panels HMI
12.	Temperature of inlet cooling water to air coolers [cooler,	1 RTD	1 set	Generator gauge/ local panel & Control Panels HMI
13.	Level of oil in bearing oil reservoirs	Sight glass	3 set	Generator gauge/ local panel & Control Panels HMI
14.	Stator Temperature recording instruments	Suitable for the total No. of RTDs used	1 set	Generator gauge/ local panel & Control Panels HMI
15.	Pressure of Air supply to brakes	Pressure gauge &Pressure transmitter	1 set	Generator gauge/ local panel & Control Panels HMI
16.	Pressure of oil supply of HP Oil Pressure System	Pressure gauge &Pressure transmitter	2 set	Generator gauge/ local panel & Control Panels HMI
17.	Pressure of Jack oil supply	Pressure gauge	1 set	Generator gauge/ local panel & Control Panels HMI

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Sl. NO	Description	Device Type	Qty.	Location
		&Pressure transmitter		
18.	Indication of brakes ON/OFF	lamp	1 set	Generator gauge/ local panel & Control Panels HMI
19.	Indication of HP Oil Pressure Pump ON/OFF	lamp	1 set	Generator gauge/ local panel & Control Panels HMI
20.	Indication of Jack Oil Pressure Pump ON/OFF	Digital meter	1 set	Generator gauge/ local panel & Control Panels HMI
21.	Unit meters for Generator (MW, MVA, MVAR, MWH, MVARH, Ammeter, voltmeter, power factor, frequency)	Multi-function meter	1 set	Generator gauge/ local panel & Control Panels HMI
22.	Tachometer (Speed Signal Generator)	Digital meter	1 set	Generator gauge/ local panel & Control Panels HMI
23.	Ammeter for monitoring of load current of space heater	Digital meter	1 set	Generator gauge/ local panel & Control Panels HMI
24.	Generator heater / OFF indicating lamps	Lamps	1 set	Generator gauge/ local panel & Control Panels HMI
25.	Double Frequency Meter	Digital meter	1 set	Generator gauge/ local panel & Control Panels HMI
26.	Excitation Transformer Temperatures	Digital meter	1 set each	Generator gauge/ local panel & Control Panels HMI
27.	Excitation Breaker ON/OFF/Trip	Indication	1 set	local panel & Control Panels HMI
28.	DAM Levels Normal/High/Very High	Digital meter	1 set each	Generator gauge/ local panel & Control Panels HMI

5.28 List of Safety Devices for The Unit (Minimum requirements are listed below)

Sl. No	Description	Device Type	Qty.	Annunciation
1.	Generator winding temperature	RTD &TSD	1 set	Alarm & trip
2.	Generator bearing temperature	ETD / RTD and dial type thermometer	1 set	Alarm & trip
3.	Machineshutdown under various faults & Excitation failure	High speed tripping relay	1	Alarm & trip
4.	Emergency shut down	Master trip relay	1	Alarm & trip
5.	Machine over speed	Speed relay & Mechanical	1	Alarm & trip

Sl. No	Description	Device Type	Qty.	Annunciation
		device Alarm & trip		
6.	DC Control supply failure	Under voltage relay	1	Alarm
7.	Oil level low	Level relay	1	Alarm
8.	Low flow Water to bearing coolers of Generator	Flow relay	2	Alarm
9.	Low flow of oil to bearing of Generator	Flow relay	2	Alarm
10.	Low pressure of water to bearing Coolers of Generator.	Pressure transmitter	2	Alarm
11.	Low pressure of oil to bearing of Generator.	Pressure transmitter	2	Alarm & Trip
12.	Lubricating oil Filter Clogged	Pressure transmitter	1	Alarm
13.	Temperature of air cooler inlet air	1 DTT in each alternate cooler	1	Alarm
14.	Temperature of air cooler outlet air	1 - do-	1	Alarm
15.	Temperature of air	1 Thermostat each in cold & hot air passages	1	Alarm
16.	Flow of cooling water to air coolers	1 FR	1	Alarm
17.	Temperature of outlet cooling water from air coolers	1 DTT	1	Alarm
18.	Pressure of cooling water to air coolers	1 PG	1	Alarm
19.	Temperature of thrust bearing pads Metal &oil	2 DTT	2	Alarm & Trip
20.	Temperature of guide bearing Pads Metal & oil	2 DTT	2	Alarm & Trip
21.	Temperature of bearing oil reservoirs	2 DTT	2	Alarm & Trip
22.	Temperature of thrust bearing pads	2 Thermostats in pads	2	Alarm & Trip
23.	Temperature of guide bearing pads	2 Thermostat	2	Alarm & Trip
24.	Temperature of cooling water outlet from bearing oil reservoir	1 DTT	1	Alarm
25.	Flow of cooling water to bearing oil reservoir	1 FR	1	Alarm
26.	Level of oil in bearing oil reservoir	2 level relays	2	Alarm & Trip
27.	Pressureof high-pressure oil lubrication system	1 PG	1	Alarm & Trip
28.	Temperature of Stator winding & core	RTD	1 lot	Alarm & Trip

Sl. No	Description	Device Type	Qty.	Annunciation
29.	Temperature of Rotor winding & Core	RTD	1 lot	Alarm & Trip
30.	Temperature of Excitation Transformer	RTD	1 lot	Alarm & Trip
31.	Vibration High	Instrument	1 lot	Alarm & Trip
32.	Air Gap Low	Instrument	1 lot	Alarm & Trip

5.29 Employer's Specification

Sl. No.	Description	Unit	Client's Requirement
1.0	**Generator**		
1.1.	Application / Designation		Hydro Power Plant
1.2.	Type of generator		Synchronous Generator
1.3.	Prime mover		Hydro turbine
1.4.	Supply system Details		
1.5.	Voltage variation	±%	10
1.6.	Frequency variation	±%	5
1.7.	Combined variation	+%	10
1.8.	Parallel operation required	Yes/ No	Yes
1.9.	Installation		Indoor
2.0	**Rating**		
2.1.	Rated Output (Continuous)	MW	Khorlochhu 4 No. of 150 MW (at rated head at P.F.0.9)
2.2.	Overload capacity (Continuous)	%	10%
2.3.	Rated terminal voltage	V	13800 (Any change in Terminal voltage to be discussed and approved by purchaser before submitting the bid)
2.4.	Rated frequency	Hz	50 (Range 47.5 to 51.5)
2.5.	Rated power factor		0.9 Lag
2.6.	No. of phases		3
2.7.	Type of duty		Continuous
2.8.	Rated short circuit ratio at MCR not less than		>1.1
2.9.	Voltage dip on sudden application of load		Not greater than 10% on 100% load
2.10.	Class of insulation of generator stator and rotor windings		Class F
2.11.	Temperature rise		Limited to Class B over the ambient of 50 deg.C
2.12.	Speed	rpm	375 RPM
2.13.	Over speed limit (Turbine run away speed)		In line with turbine
2.14.	Critical Speed	rpm	20% higher than maximum runaway speed
2.15.	Line charging capability		Bidder to confirm.

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Sl. No.	Description	Unit	Client's Requirement
2.16.	Flywheel effect (WR2)		To be included as part of the Generator.
3.0	**Construction**		
3.1.	Shaft orientation		Vertical
3.2.	Degree of protection for generator enclosure		IP-44
3.3.	Type of cooling		water cooled air coolers
3.4.	Rotor fan		Axial / bidder to confirm.
4.0	**Windings**		
4.1.	Stator winding connections		Star
4.2.	Winding material		Copper
4.3.	Method of neutral earthing		Resistance earthed
5.0	**Terminals**		
5.1.	No. of line terminals to be brought out	Nos.	Three (3)
5.2.	No. of neutral terminals to be brought out	Nos.	Three (3)
5.3.	Type of terminal boxes		Enclosed having a degree of protection IP-55
6.0	**Temperature over an ambient of 50 °C**		
6.1.	The maximum temperature of the cooling air		40 °C
6.2.	The maximum temperature of the cooling water		30 °C
6.3.	Stator winding measurement by embedded temperature detectors		80 °C
6.4.	Rotor field winding measurement by resistance method		90 dig C
6.5.	Sator core (Iron core and other parts in contact with, or adjacent to winding measurement by the thermometer)		70 dig C
6.6.	Rotor core (Iron core and other parts in contact with, or adjacent to winding measurement by the thermometer)		80 dig C
6.7.	Operating Thrust bearing Temp		80 dig C
6.8.	Operating Guide bearing Temp		70 dig C
7.0	Droop adjustment		0 – 5%
8.0	Total Harmonic distortion (THD)		As per IEC 60034
9.0	Generator unbalance operating condition		
i)	Continuous negative sequence current withstand capability I_2/I_n		As per IEC 60034-1
ii)	Maximum negative sequence current withstand under fault condition $(I_2/I_n)^2$ x t		As per IEC 60034-1

Sl. No.	Description	Unit	Client's Requirement
10.0	Noise and vibration levels		Noise≤90 dB(A) Vibrations as per ISO 7919-5 and ISO 10816-5
11.0	Current Transformer & voltage transformer details		As per Single line Diagram & Project requirement
12.0	**Online condition monitoring system**		
12.1.	Online Partial discharge monitoring system		Required
12.2.	Online vibration and Air-gap monitoring system		Required
13.0	**Miscellaneous**		
13.1.	Finish colour shade		
i)	Generator and auxiliaries		RAL 7035
ii)	Excitation system panels		RAL 7035
iii)	Panel interiors		Glossy white
13.2.	Temperature gauge panel with dial / analogue type indictors with 4-20 mA signal for remote indication and data logging in unit control panel.		To be provided & located in generator floor near generator.
13.3.	Shaft current monitoring system		Required
13.4.	Whether erection of all the equipment supplied by the bidder is required	Yes/ No	Yes
13.5.	Whether testing and commissioning of the equipment supplied by the bidder is required	Yes/ No	Yes (On returnable basis)
13.6.	Pilot lamps on Generator to know ON/ OFF status	Yes/ No	Yes

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5.30 Applicable Standards

Sl. No.	Description	Standard
1.0	Specification for rotating electrical machines - rating and performance	IEC-60034-1
2.0	Guide for testing synchronous machines	IEEE 1115,IS-7132
3.0	Method of determination of efficiency of rotating electrical machines	IS-4889 / IEC-60034-2a
4.0	Measurement and evaluation of vibration of rotating electrical machines	IS-12075
5.0	Methods for determining synchronous machine quantities from tests	IEC-60034-2
6.0	Degree of protection provided by enclosures for rotating electrical machines	IEC-60034-5
7.0	Methods for cooling rotating machinery	IEC-60034-6
8.0	Terminal markings and direction of rotation of rotating machines	IEC-60034-8
9.0	Current transformer	IS-2705
10.0	Excitation systems for synchronous machines-definitions	IEC 60034-16-1
11.0	IEEE guide for preparation of excitation system specifications	IEEE 421.4

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5.31 Mandatory Spares

Sl. No.	Description	Unit	Quantity
1.1.	Stator coils of each type installed, including associated installation materials, slot packing, wedges, ripples springs, tape, end winding support blocks, bracing components, corona protection with varnish, other associated winding and insulation material – half of each type installed to wind on generator.	Set	1
1.2.	Rotor poles and all necessary installation	12 Nos. (6 nos. shoe with coil and 6 nos. coil	
1.3.	Generator air/water cooler	Set	2
1.4.	Brush holders for generator sliprings	Set of all type	4
1.5.	Brushes for generator sliprings	Set	12
1.6.	Toothed wheel speed signal generator sensor and transducer	Sets	2
1.7.	Brush holder service kit	Set	2
1.8.	Brush holder set for shaft voltmeter	Set	2
1.9.	Brushes for shaft voltmeter	Set	2
1.10.	O-rings, packings, gaskets and seals – of each make and type installed	Set	10
1.11.	Brake shoes	Set	2
1.12.	Brake/jack unit	Set	2
1.13.	Brake/jack cylinder rings, packing, seals, etc of each make and type installed	Set	5
1.14.	Brake/jack control valves-of each make and type installed	Set	5
1.15.	Hydraulic hoses – of each make and type installed	Set	5
1.16.	Jacking oil pump – motor set	Set	1
1.17.	Bearing pads.	Complete Set	1
1.18.	Temperature, level, pressure and flow relays – of each type installed	Set	2
1.19.	Indicating instrument including associated transducers - of each type installed	Set	2
1.20.	RTDs - of each type installed	Set	5
1.21.	Thrust block with thrust ring (key)	Set	1
1.22.	Bearing oil coolers for Thrust bearing and Lower guide bearing	4 Nos. in case plugin type or 1 set in case of submerged /outside	
1.23.	AC & DC Pump & Motor for high pressure lubrication system	Set	1

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Sl. No.	Description	Unit	Quantity
1.24.	Each DTT, RTD, Pressure indicator switches, Flow indicator meters & switches ,level indicator switch ,	No. of each type	2
1.25.	Valves	Type	2
1.26.	Probes for Air gap and Vibration and any other parameters Monitoring Purpose	Type	2
1.27.	Coupling capacitor for Partial Discharge monitoring purpose	Set	1

CHAPTER 6: EXCITATION SYSTEM

6.1 Scope of Work

Scope of work under this section covers the provision of labour, tools, plants, materials and performance of work necessary for the design, manufacture, quality assurance, quality control, shop assembly, shop testing, delivery at site, site storage and preservation, insurance, installation, commissioning, performance testing, acceptance testing, training of Employer's personnel, handing over and guarantee for three years of four (4) sets of excitation equipment, as per the specifications hereunder, each complete with all auxiliaries, accessories, spare parts and warranting a trouble free safe operation of the installation. The Systems shall be suitable for Ambient, Seismic, Altitude and other site conditions mentioned in General Technical Specification.

Four (4) sets of excitation system along with the digital voltage regulator shall consist of the following main components and features:

i) Excitation Transformer, dry type,

ii) Thyristor rectifier (s) with 100% stand-by capacity complete with firing circuit, control system etc.

iii) Power supply unit,

iv) Field flashing equipment, including Transformer,

v) Field circuit breaker,

vi) Crowbar Type DC over voltage protection and discharge circuit,

vii) HMI mounted on AVR pale for local control, supervision and testing,

viii) Automatic/Digital Voltage Regulators (AVR) having the following features:

   a. Automatic/Manual control mode,

   b. MVAR/PF control mode,

   c. Power System Stabilizer (PSS),

   d. Over Excitation Limiter (OEL),

   e. Under Excitation Limiter (UEL),

   f. Volt/Hertz Limiter (VHZL),

   g. Remote communication interface (IEC 61850 or IEC 60870-5-101/103/104 compatible).

ix) Discharge resistor,

x) Digital control, indication and metering equipment,

xi) Excitation cable connecting the rotor to field breaker,

xii) Rotor temperature indicator (place of mounting shall be decided during detailed engineering),

xiii) Any other items not specified above but are necessary to complete the system for satisfactory operation.

xiv) Set of spares

6.2 Codes and Standards

The system and equipment shall be designed, built, tested and installed to the latest revision of the following applicable standards. In the event of other standards being applicable they shall be compared for specific requirements and specifically approved during detail engineering for the purpose:

Sl. No.	Description	Standard
1	Electromagnetic compatibility	IEC 801
2	Low voltage switchgear combination	IEC 439
3	Low-voltage switchgear circuit breakers	IEC 947-2
4	Units	IEC 947-3
5	Oscillatory transient	IEC 61000-4-12
6	Radiated field susceptibility	IEC 61000-4-3
7	Electrostatic discharge	IEC 61000-4-2
8	Electrical fast transient	IEC 61000-4-4
9	Instrument transformers - Part 1: Current transformers,	IEC 60044-I
10	Specification of electrical relays.	IEC 60255
11	Specification of printed boards.	IEC 60326
12	Basic safety principles for man-machine interface.	IEC 60446
13	Stabilized power supplies (DC output).	IEC 60478
14	Power cables with extruded insulation and their accessories for rated voltages 1kV to 36kV.	IEC 60502
15	Interface system for programmable measuring instruments.	IEC 60625
16	Electromagnetic compatibility for industrial process measurement and control equipment.	IEC 61000
17	Specifications of programmable controllers.	IEC 61131
18	Digital data communications for measurement and control-Field bus for use in industrial control systems.	IEC 61158
19	Definition for Excitation systems for Synchronous Machines.	IEEE 421.1
20	Guide for identification, testing, evaluation of the dynamic performance of excitation control system.	IEEE 421.2
21	High potential test requirements for excitation systems specification for static excitation system.	IEEE 421.3
22	Recommended practice for excitation system models for power system stability studies.	IEEE 421.5
23	General requirements for distribution and power transformer	IEEE C57.12.01
24	Test code for dry type transformers	IEEE C57.12.91
25	Recommended practice for transformers supplying non-sinusoidal load current.	IEEE C57.110
26	Semiconductor power rectifiers	ANSI C34.2
27	Dry type transformer	NEMA ST 20
28	National fire protection, national Electric code.	NEMA 70

6.3 Specific Design and Layout Conditions

The excitation system shall be of the static, digital, constant-voltage type with controlled thyristors. It shall feature a very sensitive, quick acting control of the generator voltage and reactive power respectively. The system shall be of reliable design with an adequate record of satisfactorily working reference plants.

The excitation power shall be supplied via a 3-phase dry type excitation transformer directly connected to the 13.8kV bus system between generator terminals and transformer terminals by means of bus-ducts.

The exciter continuous rating shall be approximately twice the rating required when the generator is operating at rated output, power factor and frequency and 110% rated voltage. The nominal exciter response shall be not less than 2. The positive and negative ceiling voltage shall be min. 200% and 160% respectively of rated voltage at rated output.

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6.4 Basic Dimensions and Ratings

Unless otherwise stated, rating, characteristics, test and test procedures, etc. of the equipment of excitation system and DVR shall comply with the provisions and requirements of the latest applicable international/ Indian Standards.

6.5 Performance Criteria and Guarantee

The Static Excitation System along with all auxiliaries and accessories shall be capable of performing intended duties under specified condition. It is the responsibility of the Contractor to supply the equipment as per the guaranteed technical particulars and shall also guarantee the reliability and performance.

The system shall be fault tolerant with redundancies at all levels. The system shall have fail safe features so that even in case of failure of all the redundant controllers, the output shall be latched on to a safe value that ensures minimum plant safety features. The Contractor shall identify and submit to the employer a detailed list of these fail safe outputs along with their safe values during detailed engineering.

6.6 Design and Construction

6.6.1 General Aspects

i) Static Excitation system offered for the generator shall have micro-processor based controls. The excitation equipment shall comprise of rectifier, power transformer, thyristors, field circuit breaker with discharge resistor, field flashing circuit, automatic voltage regulator and protection & control devices along with accessories to make it a complete system.

ii) The excitation system shall be capable of continuously supplying the maximum excitation power required to produce 110% of rated output at rated generation voltage, rated power factor and 47.3 Hz frequency with rectifier transformer supply voltage at generator voltage plus an additional capacity of 10%.

iii) With rated generator voltage, the excitation system shall be capable of providing a current to the field of not less than 1.5 times rated field current for at least 60 seconds.

iv) Excitation system shall use AC power directly from the generator output leads through a high performance dry type transformer. The system shall be able to control the generator terminal voltage under all operating conditions and facilitate joint control as specified elsewhere in the specification. The equipment shall have sufficient capacity to provide ceiling voltage and current required by generator. The voltage regulator shall provide suitable firing pulses to the thyristors for stable control of terminal voltage and quick compensation of voltage deviations caused by sudden load changes in the system. The operation parameters of excitation system shall be designed as per system/unit stability requirements.

v) The excitation system shall be capable of fully reversing its output voltage in response to a control signal in order to minimize generator iron burning in the event of generator fault.

vi) The equipment shall be capable of withstanding lightning and switching surges and dynamic over voltages to which they may be subjected and shall meet all the performance requirements and receive tests described in the specification. The equipment shall conform to the latest issue to IEEE 421 or equivalent standard.

vii) Direct current measuring equipment consisting of shunts and leads etc. and all other equipment required to provide indication of field current/voltage at AVR panels shall be furnished. Copper conductor power cables shall be provided for connection from rectifier transformer to thyristor cubicle and field breaker. DC field leads from field breaker cubicle to slip rings shall be provided and shall preferably of copper conductor power cable (armoured) and run in ducts.

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viii) The excitation system shall provide:

- Start up, field flashing and switching to the system by precise synchronizing,
- Operation of the generation at loads varying from no-load to maximum load for the generator,
- Field forcing at the set voltage response and de-excitation at disturbance in the power grid causing voltage rise or drop in the system,
- Rotor field suppression by the field discharge switch at protection operation with simultaneous inversion of the rectifying unit,
- Operation on joint control maintaining even distribution of the reactive load between machines,
- Limiting the ratio of ceiling field voltage to nominal field current by two (2) per unit without time delay as well limiting of over load by the time-inverse characteristics,
- Limiting minimum field current with set point depending on generator active power in the mode of AVR load demand from the grid,
- Protection of the generator for loss of excitation/asynchronous run,
- Protection of generator transformer from damage at frequency drop under no load conditions by lowering the voltage regulator setting suitably,
- Compensation for step-up transformer impedance,
- Limiting the maximum stator current and maximum rotor current considering thermal loading of stator and rotor winding respectively.

ix) The detailed specifications of CTs & PTs for AVR sensing shall be furnished by the bidder during detailed engineering stage,

x) The excitation system shall be capable of self-monitoring functioning of its software/hardware components etc.

xi) The excitation system shall include necessary equipment/control facilities for dynamic braking of the generator including over current protection of the Dynamic Brake system,

xii) All control, protection and monitoring installations shall be integrated into the internal control system of the excitation system.

6.6.2 Excitation Transformers

i) Three phase power shall be obtained through a three phase, self-cooled, indoor, metal enclosed, cast resin dry type transformer connected to isolated phase bus ducts. Full rated capacity taps on the high voltage winding shall be provided to accommodate the complete range of operation. The 13.8 kV H.V terminals of the excitation transformer shall be suitable for connection with isolated phase bus ducts. The transformer shall have 95 kV BIL. Calculations for the rating of excitation transformers shall be submitted for approval of the purchaser during detailed engineering stage. The metallic cabinet for the excitation transformer shall be supplied by the manufacturer. The flange connection to the isolated phase bus ducts shall be coordinated with the manufacturers of the isolated phase bus duct. Segregation between the HV terminals in the cabinet shall be provided.

ii) Since the high voltage winding of the transformer is connected directly to the generator terminals, full design consideration shall be given to the frequency increase rate, generator voltage build-up rate and insulation co-ordination. Surge transmission from high voltage side to the low voltage side shall be prevented by using earthed screen between HV and LV winding.

iii) The transformer shall be equipped with 3 x 3 (in total 9 Nos.) thermostats (PT-100 sensors) and tripping device with necessary contacts for remote indication and annunciation.

iv) The transformer shall be subjected to the dielectric tests and other standard tests as per relevant national & International standards at works and at site.

v) To maintain the generator isolated phase bus arrangement, metallic barriers of suitable design to prevent short circuit between phases shall be installed between phases inside the transformer.

6.6.3 Power Rectifier

i) Power rectifier bridges shall be silicon controlled type and shall consist of associated firing circuits complete with power fuse in series with each thyristor, gate pulse transformer, RC snubbers and status light indicator for each bridge on the front panel of rectifier cubicle. The number of bridges shall be such that one bridge is always available as redundant. With the failure of two bridges it shall be possible to continue operation at reduced load. Voltage spike protection shall be provided.

ii) Calculations for the capacity and number of thyristor bridges of rectifier shall be submitted with offer or during detailed engineering. While determining the capacity, effect of ageing shall also be considered. The rectifier PIV (Peak Inverse Voltage) rating shall not be less than four (4) times the maximum RMS voltage of the inputs. The ceiling voltage of the rectifier shall be at least 1.8 times the generator field voltage when delivering rated full load at rated voltage. The rectifier shall be able to maintain this ceiling voltage for 10 seconds. The rectifier must be suitable to work at maximum ambient temperature of 35^0 C. The rectifier shall be rated for the following duty cycle:

a) Continuous operation at its maximum rating,

b) Three phase fault adjacent to HV terminals of the generator cleared in 10 cycles,

c) Short circuit on the high voltage side of the transformer with duration of 2 sec,

d) At rated conditions, each thyristor shall not be loaded with more than 50% of its nominal current.

The static excitation equipment shall be of modular design in such a way that it can be readily removed for inspection or replacement of parts. Indicating lights shall be provided at each module to indicate and locate rectifier failure.

Each thyristor shall be equipped with a PT100 temperature sensor so that individual thyristor temperatures can be monitored. Each thyristor fuse shall be equipped with a micro-switch for blown fuse indication. Each phase shall be equipped with current measuring and the HMI shall display the different phase current.

Complete monitoring of the Thyristor Bridge shall be available on the HMI of the excitation system without the need to connect an external computer. The HMI shall provide the graphical representation of each thyristor bridge, with display of temperature, fuse monitoring, current monitoring and fan monitoring.

6.6.4 Field Flashing Equipment

i) All equipment necessary to automatically flash the field shall be provided to ensure proper buildup of voltage on manual and automatic start-up.

ii) The power required for field flashing equipment shall be taken from 415V, 3 phase 50 Hz auxiliary power supply from UAB and alternatively from the station 220V D.C. battery supply till the generator has built up sufficient voltage and automatic changeover of field supply from excitation transformer connected to the generator terminals through IPBD shall take place as per the provision made by the generator supplier in this regard. The kVA rating and voltage ratio of field flashing transformer (forming part of supply) and requirement of AC / DC power and its duration for field flashing shall be indicated

in the tender. While using batteries for field flashing over voltage protection shall be provided and shall also be coordinated with suppliers of LV system / 220V DC system, provided as a part of excitation equipment.

6.6.5 Excitation Breaker and Resistor

i) An A.C or D.C. circuit breaker shall be provided for isolation of the field circuit for ensuring definite disconnection of field from the supply source and subsequent discharge of energy of the field circuit through field discharge resistor of adequate rating in the event of a severe internal fault or three phase short circuit fault on generator terminals or short circuit fault on the slip rings. The magnetic field energy in such case shall be dissipated through this field discharge resistor of nonlinear type which shall get connected across the field during such operation.

ii) The field breaker shall comprise of an electrically operated and adequately rated equipped with sufficient auxiliary contacts for control, monitoring and protection functions.

iii) A moulded case circuit breaker shall not be acceptable.

iv) LED lights shall be mounted on the exterior of the breaker cabinet to indicate CLOSED (red) and OPEN (green) position of the breaker.

v) Provision for manual operation of the circuit breaker shall also be made by means of control switches provided on excitation panel. In normal case operation shall also be automatic through sequential controller.

6.6.6 Digital Voltage Regulator

i) The excitation system shall be provided with two auto-channels (Channel-1 & Channel-2) and one manual channel (Channel-3) for automatic voltage regulation, excitation control and indication. Each channel shall be equipped for auto operation with facility of selecting either channel in “Auto” or “Manual” mode. Each channel shall be capable of being the “Main” or “Standby” channel. The voltage regulator shall be of the digital continuous acting type, taking its input signal from the averaged 3- phase voltage at the generator terminals.

ii) When generator is in parallel operation with other generators and/or with the grid the AVR shall remain stable and no voltage oscillations shall occur.

iii) When operated manually, the field current shall be adjusted by manual control and the regulation with reference value setting.

iv) Auto and manual operation control circuit shall be independent.

v) The digital circuitry shall be designed conservatively so as to be reliable and practicable.

vi) The voltage regulator shall automatically actuate the controlled rectifier and shall be capable of performing the following functions:

a) Maintain the average 3-phase generator voltage within plus or minus 5% without hunting when operating under steady load conditions for any load or excitation within operating range of generators. The control range shall be 10% of the rated voltage,

b) After the generator voltage attaining initial maximum value (neglecting the instantaneous rise) following any load rejection up to 110% of the rated load, AVR shall restore the generator terminal voltage to a value not more than 5% above or below the voltage being held before load rejection and shall maintain the voltage within these limits throughout the period of the generator over speed,

c) Under steady condition, for any over speed up to 130% of normal, maintain generator voltage within plus or minus 5% of the value that the AVR was holding before over speed without taking into account line drop compensation. Also under

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steady speed conditions for an over speed between 150% to maximum permissible over speed to maintain generator voltage within plus or minus 10% of the value the voltage regulators were holding before over speed,

d) Permit continuous stable operation of the generator under control of voltage regulators when meeting the line charging requirements,

vii) The voltage regulator shall have following additional features:

a) Reactive power joint control function devices to ensure satisfactory load sharing during parallel operation of the generators shall be integrated in the station control computer to be included under SCADA System supply. Paralleling of generators shall be achieved on 400kV side of power transformers. Necessary coordination in this regard shall be done by the bidder with the supplier/manufacturer of 'Unit Control System' and 'SCADA System',

b) An adjustable minimum excitation limit device shall be excited from potential and current transformers and shall automatically limit the decrease of the generator excitation below that value which may result in pull-out of the generator when in operating condition. The characteristics of the minimum excitation limiter shall closely match the generator capability curves,

c) An adjustable maximum excitation limit device shall automatically limit the excitation of the generator to safe value with the excitation under control of the regulator. The device shall have an adjustable time delay feature to permit short time operation (subject to thermal limitation) with ceiling excitation.

d) Prevent over fluxing of generator transformer,

e) Follow up circuit: Provision shall be made to follow-up changes and constantly match the manual control system with the auto-control in "auto" mode so that in case of sudden change to "manual" there will be no dip in the generator voltage. An alarm and visual facial indication shall be provided to indicate change from "Auto" to "Manual". Automatic changeover shall also be possible from "Auto to Manual" in case of loss of main feed back-up by any of voltage transformer fuse failure,

The switching from manual to automatic shall be possible only manually.

f) **Line Drop Compensation:** A provision shall be made for inclusion of line drop compensation feature,

g) The voltage regulating system shall include device for improving the damping of active electro-mechanical oscillations. These devices shall operate to supplement the voltage regulating action by adding an additional control signal into the excitation system input. This supplemental input signal shall influence the excitation system so as to cause a change in field current of the machine for stabilized operation. The adaptive control function feature to the slip stabilizer shall be provided. The function of the control is to optimize the setting of the slip stabilizer to suit the different configuration system,

h) Exciter over voltage protection of crow bar type shall be provided to work under all conditions of regulator in or out of operation or mal operation. The protective circuitry shall be responsive only to the exciter terminal DC voltage and its operation shall be separated from the limiter and its associated controls. The equipment shall have an adjustable time delay feature and a means of adjusting the operation voltage level so as to permit operation that does not interfere with normal regulator functions. If an exciter output over voltage condition persists for a sufficient time such condition shall initiate the following action:

- To operate generator lock out relay and trip main and field breakers,
- To provide annunciation,

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- Power supply to the control circuit shall be provided from the generator supply through suitable step down transformer. In addition to this, station battery supply shall be used as a redundant to above supply through suitable DC-DC converter. Necessary coordination in this respect shall be done with suppliers of 220V DC System and Cables.

i) Stator current limiter: The stator current limiter shall act immediately in under excited range. The time delay in over excited range shall enable a temporary overloading of the machine.

j) Automatic changeover for Channel-1 to Channel-2 or vice versa in case of trouble in running channel shall be possible.

k) Manual operation with separate excitation from station supply for dry out run and testing for 0–130% rated generator voltage in open circuit and 0-130% rated generator current in short circuit.

6.7 Excitation Control and Indication

The voltage regulation and excitation control equipment shall be suitable for local, manual and automatic microprocessor based control, suitable circuit containing position switches and internal wiring within the equipment required to give correct operation & indication and all equipment necessary for the operation shall be provided by the supplier. All equipment required to provide smooth change over from "auto" position of voltage regulator to "Manual" position and vice versa shall be provided. Regulator balance indicator shall be provided for this purpose.

For the control, monitoring/surveillance and alarm/emergency system, the following functions shall be foreseen:

i) Control for generator's proper excitation and de-excitation,

ii) Processing of input signals and output signals as interface to the starting automatic and to the control system,

iii) Supervision of excitation system with local alarm indication, alarm storage and acknowledgement,

iv) Output of summary signals "excitation fault warning" and ''excitation fault tripping/initiation''

v) Local operation devices/element,

vi) Local measuring/metering devices for generator voltage, generator current and field current.

6.8 Interfacing with Unit Control System and SCADA System

The communication interface for Excitation System shall be compatible to IEC 61850/IEC 60870-5-104 for interfacing with the plant SCADA and Unit Control System.

6.9 Cooling of Thyristors

i) The equipment shall be cooled by forced air, 100% capacity reserve fans shall be supplied for this purpose with provision of automatic switching to the reserve unit actuated by fall in pressure and rise in the temperature of exit air on the main unit. The Thyristor Bridge shall have air-flow monitoring to detect loss of air-flow and automatically start the redundant fan without interruption of operation. It shall also be possible to manually switch fans from Local HMI screen of the excitation system.

ii) The control system shall permit manual and automatic selection of either fan unit for stand-by operation. If both the units fail, a time delayed differential pressure and exhaust air temperature switch can be used to trip the generator and field breaker.

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6.10 HMI Panel

The local HMI panel shall be a colour 15 inch screen with touch technology and mounted on the cabinet door of the excitation system. The HMI shall be fully operational without requiring the use of a dongle software key. In addition to control and annunciation, the panel shall encompass easy access for technical personnel to make parameter changes, perform step response tests and other compliance testing. As a minimum the panel shall include:

i) Operation (Excitation ON/OFF, raise/lower, change of control mode AUTO/MAN),

ii) Indication (Metering, control mode, limiter and PSS status),

iii) Data logging capability with at least six (6) different trigger signals with pre-trigging recording,

iv) Alarm list / Sequence of Event feature with 1ms sampling rate,

v) Step response capability for analyzing AVR, PSS and limiter performance,

vi) Easy access to tuning parameters for AVR, PSS and limiters,

vii) Diagnostic screen for thyristor bridge with display for temperature measuring, blown fuse, current measuring, cooling fan monitoring)

It should be possible to download a step response record to USB memory key or via connected network for further analyze or use in reports for compliance testing. The file format shall be .csv or ACSII text for processing with third party software.

Parameters that are changed should be automatically saved in non-volatile memory so that they are not affected by loss of power to the controller.

The panel shall have a minimum of three (3) password levels, for viewing access only, operation access and technical personnel access.

It shall be possible to mount the same HMI in a remote location for remote access. The remote HMI panel shall be capable of interrogating each excitation system through a drop-down menu that allows the user to choose the system to be interrogated (optional)

6.11 Software Tool

The supplier shall furnish a software tool to facilitate program logic changes. The software shall be pre-loaded on a laptop PC with all licenses and connection accessories included.

The laptop shall connect with the excitation controller through serial communication, RS-232 or equivalent. In addition, a closed-loop simulation software tool shall be furnished and loaded onto the supplied laptop PC. The closed-loop simulation tool will be utilized during the training and shall be retained by the KHPL to facilitate future training of personnel.

6.12 Excitation Cubicles

All the equipment of static excitation and AVR shall be suitably housed in sheet metal, dust proof cubicles. All these cubicles shall be located at one place in a row without any gap in between. The dimensions of the cubicles shall be identical to present a neat and functional line up. All the excitation and AVR cubicles shall be provided with minimum IP-54 class of protection.

6.13 Protection of Static Excitation Equipment

The excitation equipment shall be protected against internal faults, failure of thyristor bridges, cooling fans etc. for which contacts shall be provided for alarm and shutdown of the unit. The items of protection covered shall be the following but not limited to:

i) Excitation equipment internal faults,

ii) Current asymmetry protection more than two stacks faulty,

iii) Over voltage protection for detection of sustained field over voltage (Crow Bar Type),

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iv) Over current protection for overload and short circuit protection of the excitation transformer and rectifiers,

v) Cooling fans failure (main and reserve),

vi) Loss of regulator DC power,

vii) Failure of thyristor firing circuit,

viii) Individual cooling fan failure,

ix) Rectifier cubicle exit air high temperature,

x) Failure of AVR,

xi) Current asymmetry, one thyristor stack faulty,

xii) Operation at minimum excitation limit,

xiii) Operation at maximum excitation limit,

xiv) Excitation transformer winding temperature,

xv) Operation of slip stabilization unit,

xvi) Failure of field flashing circuit equipment,

xvii) Prevent over fluxing of the transformer.

6.14 Dynamic Braking

The Dynamic Braking equipment shall be employed to reduce the rundown time of the synchronous generator after shutdown of the machine.

Dynamic braking shall be obtained by shorting the stator terminals of the generator.

With the tripping of the generator circuit breaker and generator field circuit breaker following a shutdown sequence, the dynamic braking mode is selected. Once the machine runs down to a predetermined speed, the shorting isolator closes to short circuit the stator terminals. Excitation shall be applied to the generator field through thyristor bridge of Static Excitation Equipment by rectifying the secondary voltage of transformer. Rating of the transformer shall be adequate to provide excitation current to the generator to maintain the rated current flow in the stator windings.

Detail calculation for selection of predetermined speed of machine for application of dynamic braking shall be furnished during detailed design stage for approval.

The dynamic braking equipment shall derive input power from Station Auxiliary 415 V, 3 phase supply.

During the dynamic braking mode of the machine, a command is given to the firing circuit of the manual channel to provide fixed output from the Thyristor Bridge corresponding to the rated stator current. Once the machine speed reaches a predetermined low speed the field breaker & supply from station auxiliary are tripped, following which the dynamic braking isolator is also opened.

An over current relay shall be provided to protect auxiliary supply circuit of the dynamic braking equipment against the over current.

6.15 Excitation Connections

Excitation power cable connections between the generator slip rings and the field breaker cubicles shall be provided. The power cables shall be of adequate copper cross-section to continuously carry the rated current of the excitation system and the maximum current for 10 seconds. They shall be made of the heat-resistant type.

The cables shall be adequately spaced and supported with consideration to the electro-mechanical forces involved and designed to prevent undue heating during continuous heating.

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6.16 Tests

6.16.1 Shop Tests

Type tests shall be conducted to verify that all components of the excitation system perform satisfactorily for its design and rating assigned. All equipment proposed according to this specification shall be type tested in accordance with the relevant IS/IEC standards.

The type tests are not to be mandatory if similar typical system have been type tested and test certificates for relevant tests are accepted by the Employer.

The contractor at his own costs shall conduct the type test (s) for which certificates is not acceptable to the Employer.

Routine tests shall be conducted to demonstrate that the excitation system and accessories offered meet the requirement of specification.

These tests shall include material and tests during manufacture/final inspection as per the manufacturer's practice/relevant standards. The excitation system shall undergo regular routine tests and special tests including the following as per relevant standards:

i) Individual apparatus routine test,

ii) Dielectric test,

iii) Visual checks of finish, marking, inscriptions etc.

iv) Full scale functional test. For this test all equipment specified under this section shall be hooked up together in the same way and with the same elements as will be used later by site installation,

v) The rated current test at reduced voltage and closed-loop simulation testing of AVR, limiters and PSS (special test),

vi) System and application software functions shall be fully verified. All input signals shall be simulated and output signals verified from cubicle input to cubicle output.

6.16.2 Field Tests

All field tests including tests during installation, pre-commissioning, commissioning, performance and field acceptance tests shall be conducted by the Contractor, in the presence of Owner's representative.

The contractor shall verify the correct operation of all excitation system features, both for off-line and on-line operation, including all control loops, limiters, power system stabilizer (PSS) etc. All operational commands and indications to/from the exciter shall be verified for communication with the unit control and plant control systems, hardwired I/O and HMI screen.

Procedure to be adopted for conducting the operational, pre-commissioning, commissioning, performance and field acceptance test shall be submitted well in advance, at least six (6) months before start of relevant testing for Owner approval.

The excitation system shall undergo all field tests including the following as a minimum to demonstrate the operational capabilities as per the intended requirements:

i) Checks on the wiring of the interconnections,

ii) Dielectric tests as well as measurement of insulation resistance of each circuit,

iii) Load rejection test to determine maximum voltage rise under AVR control,

iv) Excitation system frequency response (phase & gain) curves of each generator,

v) Overall response of machine and excitation system voltage changes,

vi) Tests of maximum excitation limiter,

vii) Tests of volts per cycle regulation,

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viii) Minimum excitation limiter test,

ix) Effectiveness of voltage regulator forcing action in demagnetizing the main regulator field,

x) Voltage build up test on auto-control,

xi) Steady state accuracy of voltage control from no load to full load,

xii) Test to determine the range of voltage adjustment on auto control and manual control,

xiii) Dielectric test for excitation transformer,

xiv) Adjustment of AVR,

xv) Test of ceiling voltage and steady state ceiling voltage,

xvi) Test of excitation system operation at simulation of certain components failure,

xvii) Functional checks of all instruments, protective relays, auxiliary relays, switches, etc. including calibration of all instruments, indicating meters and relay settings,

xviii) Functional check of systems for local/remote and auto/manual control, interlocking and annunciation, etc. in conjunction with the actual equipment to be protected and/ or controlled,

xix) Final adjustment of the voltage, current and time settings.

6.16.3 Test Report

Shortly after completion of the field acceptance tests the Contractor shall prepare and forward draft copies of the field acceptance test report to the Employer for review. After review and acceptance, the contractor shall furnish six (6) copies of the final report.

6.17 Drawings, Documents and Design Calculations

6.17.1 Design Memorandum

The Contractor shall submit to Employer a design memorandum prepared in accordance to clause 2.5 “Design Memorandum”, of General Technical Specification.

6.17.2 To be enclosed along with Bid

i) Drawings showing the number and dimensions of the cubicles for each excitation system.

ii) Drawings showing the front view of the cubicle including operation and measuring instruments.

iii) Block diagram with the individual function blocks of the excitation system.

iv) The detailed product catalogues along with technical specifications of the excitation system (functional description) and the technical data of the main components of the system.

6.17.3 To be submitted after award of contract

The contractor, after the award of the contract, shall submit the drawings minimum for the following for review and approval:

i) An internationally recognized designation system for equipment and their location shall be consequently used in all drawings and documents. The same designations shall be used for marking of equipment and devices,

ii) Detailed schematic drawings of each system with BOM,

iii) Connection diagrams,

iv) Cable routing diagram within panel and panel to panel,

v) Arrangement drawings for equipment within the plant,

vi) Cable routing diagram within panel and panel to panel,

vii) Arrangement drawings for devices and modules within the cubicles,

viii) Signal lists,

ix) Material lists,

x) Listing of adjustments,

xi) ON/OFF sequence of the excitation,

xii) OGA and foundation drawings,

xiii) Test protocols,

xiv) Input/output list,

xv) Operation and maintenance manual,

xvi) Detailed quality assurance plan giving complete specifications of the materials and specification for inspection and testing of control system,

xvii) Data sheet,

xviii) Shop tests and inspection procedures for various equipment,

xix) Other drawings or information in order to enable the purchaser to check suitability of offered equipment.

6.18 Design Calculations

The contractor is required to submit all the calculations necessary for excitation system to the engineer for approval during detail engineering.

6.19 Instruction Manuals

The supplier shall prepare manuals covering the information and instructions pertaining to the following sections for guidance during storage, installation and operation & maintenance.

6.20 Manual for Storage, Preservation and Handling at Site

This manual shall contain detailed information about the system of marking adopted to show sling points, restrictions regarding position of transport of any package & position of application of any cradle provided for use during transport or site storage/preservation of goods for all items. Four (4) copies of such manual shall be submitted to the purchaser:

6.21 Manuals for Erection, Testing and Commissioning

This document shall include full and detailed instructions regarding the procedures and precautions to be observed during installation of excitation systems and associated accessories including the use of installation equipment. It shall also include the performance parameters required to be met during erection to demonstrate that the equipment erected is within the tolerance specified in the contract.

The testing and commissioning section shall include full detailed directions for the methods & procedures to be followed, the parameters to be observed & recorded in checking the accuracy of installation and carrying out site tests as required under the contract. It shall also include the performance parameters required to be met for site tests, description of all equipment & instruments provided for these tests and of their use. Four (4) copies of such manual shall be submitted to the purchaser:

6.22 Manual for Operation & Maintenance

This shall include complete instructions for operation and maintenance of excitation system and associated equipment not only during the defect liability period but also during its operating life. The directions shall be set out simply, clearly and systematically as per General Technical Specification.

Schedule of Similar Installations

The bidder shall furnish a list of similar type and of similar or higher rating equipment supplied and duly installed & commissioned by him along with the bid. The bidder shall furnish the place and the year of supply and their commissioning dates along with the particulars of equipment supplied.

Delivery, Installation and Commissioning

The Contractor shall follow the general requirement of Delivery, Installation and commissioning as per relevant clauses in General Technical Specification.

Schedule of Requirements (BOQ)

The tentative schedule for supply, installation, testing and commissioning of excitation system and associated auxiliaries/accessories as per specifications, not specifically limited to, are listed here under:

i) Four (4) sets static excitation equipment and DVR complete in all respect,

ii) All power cables, control cables and special cables, cable racks, cable glands, lugs, terminals, connectors etc. for cabling between equipment and devices covered in this chapter,

iii) One (1) set of spare parts in accordance to clause 6.5 of this chapter,

iv) One (1) set of special tools and instruments,

v) One (1) laptop PC with pre-loaded software,

vi) Four (4) nos. of rotor temperature indicator.

Any other item(s) not mentioned specifically but necessary for the satisfactory completion of scope of work defined above, as per accepted standard(s)/best international practices.

6.23 Spare Parts

The spare parts mentioned here under are meant for use by the Employer during operation and maintenance stage and shall not be used as erection spares required during installation.

6.23.1 Mandatory Spare Parts

In accordance to the General Technical Specifications (GTS), the following mandatory spare parts shall be supplied by the contractor.

Sl. No.	Description	Unit	Qty
1	Electronic cards pertaining to the AVR, comprising one (1) piece of every kind, type or size.	Sets	2
2	Electronic modules not included in the AVR but necessary for the control of the thyristor circuits	Sets	2
3	Excitation Transformer complete with all accessories	No.	1
4	Rectifier cooling fan complete with motor and all accessories	Set	1
5	Thyristors bridge complete with fuses and all accessories	Sets	2
6	Field breaker with all accessories	Nos.	2
7	Field breaker operating coils (trip and closing coils)	Sets	3
8	Field flashing rectifier	Sets	2
9	Field flashing breaker with all accessories	Nos.	2
10	Field flashing breaker operating coils (trip and closing coils)	Sets	3
11	Ancillary Relays, circuit breakers, contactors, switches, indications, etc.	Sets	2
12	Power pack (consisting of AC/DC and DC/DC	Sets	2

Sl. No.	Description	Unit	Qty
	convertor) of each type		
13	Blown fuse detectors	Sets	1
14	Fuses of each type used	Sets	3
15	Auxiliary transformer/Control Transformers	No. each type used	1
16	Blocking diodes for field	Sets	2
17	Fans with its accessories	Nos.	6
18	HMI Module	No.	1

Note: A set is defined, as the total number required for one generator.

Besides above, the Contractor shall recommend any additional spare parts, which in his opinion are necessary for satisfactory operation of the system. However, the procurement of these recommended spares shall be at the discretion of the purchaser. The additional recommended spare parts shall be indicated in the Data Sheets of Volume-6.

6.24 Recommended Spare Parts

Recommended spare parts shall be supplied in accordance to clause 3 "Spare Parts and Tools" of General Technical Specifications.

Guaranteed and Other Technical Particulars

The Contractor shall follow the Guaranteed & Other Technical Particular requirements as specified in Data Sheets of Volume-6.

6.25 Tools and Instruments

6.25.1 General

The Contractor shall supply all necessary tools and Instruments etc. for installation, repair and maintenance in accordance to clause 3.2 "Tools and Instrument" of General Technical Specification.

6.25.2 Special Tools

The contractor shall supply all the necessary special tools and devices for installation, repair and maintenance of each item of equipment/component supplied under this section as recommended by manufacturer(s). The list of these items including their make and detailed specifications shall be submitted for acceptance by the Employer.

All special tools shall be clearly marked to identify their use and shall be made available for the installation works to be undertaken by the Contractor. Special tools shall be shipped with the first consignment of equipment to be installed.

The tools shall be delivered to the Employer prior to taking over, in perfect condition or be replaced, if necessary, with new tools of equal or better quality than the original ones.

6.25.3 Tools for Erection and Installation

The contractor shall bring his own tools, devices, testing instruments/equipment to site in order to erect and install the complete equipment delivered under this section. These shall remain the property of the contractor unless otherwise agreed to take over any/all of these at mutually agreed conditions.

For on-site assembly, the contractor shall use the same assembly tooling and procedures as those used in the shop.

6.25.4 Testing Instruments

The contractor shall supply testing instruments of internationally reputed make having proven acceptance in the field for use during testing and commissioning and operation stage. The list

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of these items including their make and detailed specifications shall be submitted for acceptance by the Employer.

All other electrical testing and measuring equipment are covered in the relevant section of particular technical specification. The proposed list of special tools must include the following in addition to tools recommended by manufacturer(s):

i) Two (2) Sets of Double channel CRO storage type,

ii) Two (2) Sets of digital multi-meters.

6.26 Quality Control and Assurance

The Contractor shall submit detailed Quality Assurance Plan and Inspection Schedule for Employer's review and approval in accordance to clause 12 of General Technical Specification.

6.27 Deputation of Engineers for witness of Tests, Inspection & Training

The Employer's representatives shall be deputed for the following purposes.

Sl. No.	Description	Batch	No of Days	No. of Engineers and Technicians
1	Training at the plant and design office	2	4	3 Engineers 3 Technicians
2	Shop Inspection and Test	As and when required for inspection and test		

The training of employer's personnel shall be as specified in clause 11.0 "Training of Employer's Personnel" of General Technical Specification.

6.28 Deviations from Specifications

All deviations from these specifications shall be separately listed in the requisite performa of the bid document, in the absence of which, it will be presumed that the provisions of the specifications are fully complied with by the bidder. However, the deviations, which are better than the specifications shall be considered by the purchaser.

6.29 Completeness of Contract

Any fittings, accessories or apparatus required for successful commissioning though may not have been specifically mentioned in the specification but are usually necessary for the completeness of the works shall be deemed to be included in the specification and shall be supplied by the bidder without any extra cost to the purchaser.

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6.30 Employer's Specification

Sl. No.	Description	Unit	Client's Requirement
1	**Excitation System**		
1.1.	Type of excitation		STATIC
1.2.	Frequency range		±5%
1.3.	Voltage regulation from no load to full load with AVR		±0.5%
1.4.	Range of voltage setting on auto control		80 - 110% of UGn
1.5.	Range of adjustment on manual control		0 - 110% of IFn
1.6.	Ceiling voltage	At least 1.5 P.U. for 10 seconds	
1.7.	Excitation system response ratio		>= 2.0
1.8.	Excitation system response time	msec	<20ms
1.9.	Manual channel shall follow auto channel within	%	<0.5
1.10.	Field forcing capability during bolted fault on generator terminals	%	150
1.11.	Inertia constant	%	>1.1
1.12.	Operation modes of voltage regulator	Two auto and one manual Channel, Microprocessor based, continuously adjustable	
1.13.	Line drop compensation feature required	%	0 – 10%
1.14.	Whether following features required		
i)	Maximum excitation limiter		Required
ii)	Minimum excitation limiter		Required
iii)	Over fluxing (volts / hertz) limiter		Required
iv)	Reactive drop compensator		Required
v)	Active load stabilization / Power System Stabilizer PSS		Required
vi)	Stator Current Limiter		Required
vii)	Field current Limiter		Required
viii)	Load angle Limiter		Required
ix)	Over fluxing limiter		Required
x)	Power factor regulator/MVAR (megavolt ampere of reactive power) regulator		Required
xi)	Rotor Current Regulator (Manual Operation Mode)		Required
xii)	Auto Tracking and Transfer between Automatic and Manual Mode		Required



CHAPTER 7: ISOLATED PHASE BUS DUCT (IPBD)

7.1 Scope of Work

This specification covers the requirements of sizing, design, engineering, manufacture, inspection, testing at BIDDER's and/or his sub-vendor's works, packing, transportation, delivery to site, including transit insurance, erection, testing, commissioning and performance testing of metal enclosed isolated phase bus duct and its associated equipment/accessories. VENDOR shall also furnish detailed structural drawings and foundation details along with supporting calculation.

IPBD (Main Bus): 10000A, 63kA/3s And IPBD (Tapping Bus): 200A, 120kA/3s, 13.8 kV, the continuous current rating of the bus duct will be suitably selected to match the maximum output of the generator. Required number of potential transformers, current transformers, surge arrestors will be provided for metering and protection.

All the 13.8 kV system will be conveniently located to facilitate tapping of power from the bus duct. IPBD tap offs are taken from the main run for connecting Unit Transformers. The neutral side generator bus duct is terminated at the neutral grounding equipment panel, which houses a neutral earthing transformer and neutral earthing resistor.

The following list of items/systems are covered under this specification for each Generator unit. Additional details refer data sheet-A / SLD.

i) IPBD

ii) NGT with NGR

iii) LAVT Cubicle.

iv) Dynamic Braking Switch Cubicle.

7.2 Codes & Standards

The design, material, construction, manufacture, inspection, testing and performance of equipment shall comply with all currently applicable standards, codes of practice, regulations and safety codes in the locality where the equipment will be supplied & installed. Nothing in this specification shall be construed to relieve the CONTRACTOR of this responsibility.

The VENDOR shall ensure that instruments and gauges to be used for testing and inspection shall have valid calibration and the accuracy can be traced to National and International Standards as applicable.

7.3 Constructional Features

The cross section of the bus enclosure shall be circular.

The entire bus duct shall be designed for indoor/outdoor installation with a dust, vermin and weatherproof construction. The degree of protection shall meet the requirement of water and air tightness test specified as per codes.

Under normal operating conditions, the hot spot temperature of the enclosure shall not exceed the value as per codes, including the heat released by the current transformers.

Joints consisting of rubber bellows shall necessarily be provided on the bus enclosure at the following equipment terminations - (a)Generator transformer, (b) Unit Auxiliary Transformers, (c) Voltage transformer & Surge Protection Cubicle, (d)Excitation transformer cubicle for Generators with Static excitation, (e) Between generator terminals & adapter box & between adapter box & busduct on Phase as well as neutral side of the generator, between Gen phase busduct & Dynamic brake switch.

Bellow joints of metallic/rubber shall be provided at the following locations. In either case electrical continuity shall be ensured by providing flexibles across the bellows:-

i) One end of Generator Circuit Breaker (GCB) (if GCB is applicable) shall be welded directly to the bus duct and the other end shall be provided with the bellow.

ii) In the run of the bus duct outside the TG foundation block to avoid transfer of vibration of TG pedestal.

Flexible expansion joints for the enclosures shall be provided in the run of the bus duct wherever deemed necessary, by the VENDOR.

Isolated phase terminal enclosures shall be provided with flanged ends with drilling dimensions to suit the flanges at equipment like generator, generator transformer, unit auxiliary transformer, voltage transformer and surge protection cubicle, generator neutral earthing cubicle etc. Necessary arrangement shall be made in the terminal enclosures to reduce the excessive heat due to the eddy current circulation.

At the generator end, suitable arrangement such as hydrogen escape vent through a breather shall be provided to allow escape of hydrogen which might leak into the adopter box from generator terminal bushing.

In the case of generator neutral side terminal enclosure, the star point of the generator shall be formed in the enclosure after the current transformers are mounted over the bus conductor of individual phase. A single bus duct of required length and rating as per project requirements and flange connections at either end shall be provided. Matching flanges shall be provided on the star side of the enclosure and neutral earthing cubicle to connect the single bus duct.

At the locations of insulators, current transformers, removable flexible joints, disconnecting links, etc., inspection covers shall be provided on the bus enclosure for periodic inspection of interior parts.

Bus enclosures shall be insulated with respect to the supporting structure by providing 1.1 kV grade insulators made of DMC with polyester resin that has been stabilized against U.V. radiation.

Necessary earthing arrangement as applicable for continuously/ non-continuously bonded type of bus duct shall be provided with clamps to receive connection to the plant earthing grid.

Continuous sun shield made of non-magnetic material mounted on the bus duct enclosure shall be provided over the entire length of the outdoor portion of the bus duct.

The material of the bus conductor shall either be aluminium alloy or copper as specified in Data Sheet-A1. The grade of the alloy shall be subject to PURCHASER's approval.

The bus conductor/joints shall be designed to carry the rated current under normal site operating conditions without exceeding the temperature rise as stipulated in Data Sheet-A1

The bus conductors shall withstand without permanent deformation and deterioration of conductor material, the stresses consistent with the self-weight, momentary short circuit current and seismic forces.

Joints in the bus conductors shall provide an efficient, electrically continuous, and mechanically strong connection. The cross-sectional area of the links shall be larger than that of the main conductor.

Flexible aluminium/copper connectors welded to the bus conductors shall be provided wherever deemed necessary, to take care of expansion and contraction of bus conductors.

Bolted rigid joints provided as disconnecting links and to facilitate removal of CTs shall be of the same material as the bus conductor, and the contact surfaces shall be silver plated to ensure an efficient connection.

Flexible braided copper connections shall be provided at the terminals of generator, generator transformer, unit auxiliary transformer, both the sides of GCB, excitation transformer, voltage transformer and surge protection cubicle and neutral earthing cubicle. The mating surfaces of bus conductor as well as the flexible connector shall be silver plated. All the joints shall be tested for temperature rise to prove the adequacy of the design. The maximum temperature rise at the joints shall be less than the specified temperature rise for the bus conductors.

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Short circuiting device for the purpose of checking stability of protective relays before commissioning, continuously rated same as that of the main bus conductor current shall be supplied at a location adjacent to the disconnecting links or as specified in Data Sheet-A1.

Wherever the bus duct passes through the plant building wall, from indoor to outdoor, a wall frame assembly with seal-off bushings shall be provided. Each phase of the bus duct shall be equipped with seal-off bushings wherever necessary.

7.4 Painting

The inside of the bus enclosure shall be black colour painted in matt finish to facilitate heat dissipation. The paint shall not deteriorate at specified maximum temperature of the bus conductor and enclosure.

The outside of the enclosure shall be given a finish as per the PURCHASER's requirement specified in Data Sheet-A1.

All welded joints shall be cleaned with stainless steel wire brush and white spirit to remove all dirt, grease, oil or any other foreign matter.

Primer painting shall consist of a coat of etch primer followed by two coats of epoxy primer. The mixing ratios shall be as recommended by primer manufacturer.

Finish paints for touch-up at site.

7.5 Components & Accessories

All components and accessories of the IPBD system shall be of reputed make and subject to approval of Purchaser/Consultant and the makes & important technical details shall be specified while furnishing the Bid.

All support structures for the busducts (only foundation with pedestals will be provided by the owner).

Foundation bolt for support structures shall be provided.

Spare parts required for successful commissioning. Bidder shall furnish the list of items in his offer.

7.6 Generator Neutral Earthing

Generator neutral shall be earthed to limit the earth fault current as recommended by generator manufacturer through NGT & NGR. The transformer & resistor shall be suitably sized & the BIDDER shall furnish detailed calculations for arriving at the value for the PURCHASER'S approval.

The neutral isolator shall be suitably rated. The generator neutral isolating switch shall be interlocked such that only one neutral is closed at a time when more than one generator is running (during parallel operation of generators). The isolator shall be suitable of online & motorised operation.

The cubicle shall house the resistor, isolator, CTs, cable boxes accessories as required & as detailed in the single line diagram.

The CTs shall cast epoxy resin type.

7.7 Inspection & Testing

All routine tests as specified in relevant standards shall be conducted at the works and all site tests shall be conducted including supervision as per relevant standards at site after the complete bus duct is assembled. In addition, the completely assembled bus duct shall be tested for air tightness and water tightness test.

Certified copies of reports/certificates including type tests carried out as per relevant standards on similar type and rating of the equipment within last five years shall be furnished for review and approval. In case the type test reports are not found to be meeting the specification

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requirements or older than five years, then the VENDOR shall conduct all such tests free of cost and submit the reports for approval.

Type test assembly shall comprise of all the major components such as flexibles, bends, CTs, Seal-off bushings, enclosure bellows, welded joints, disconnecting links, etc., and shall depict the actual site installation. The components used in the type test assembly shall not be used in the bus duct sections being supplied for the project.

Functional tests shall be carried out to demonstrate the specified control and interlocks.

Copies of the test certificates for all brought out items shall be submitted for the PURCHASER'S approval.

7.8 Employer's Specification

Sl. No.	Items	Units	Design Particulars
1	Type of bus duct		Normally natural air cooled/ Forced air cooled beyond 10,000A rating
2	Nominal service voltage/rated frequency	kV (rms)/Hz	13.8 kV, 50 Hz
3	Rated voltage class	kV (rms)	17.5 kV
4	Continuous current rating of bus duct under site conditions		
4.1	Main run	A	
4.2	Delta run	A	
4.3	Common tap-off to UATs	A	
4.4	Individual lead to UATs, VT & SP cubicle, NGR cubicle	A	
5	Basic impulse withstand level (1.2 x 50 micro sec wave)	kV (Peak)	
6	One minute power frequency dry withstand voltage	kV (rms)	
7	Dynamic withstand current		
7.1	Main	kA (Peak)	
7.2	Delta	kA (Peak)	
7.3	All tap-offs	kA (Peak)	
8	Short time current for one second		
8.1	Main	kA (rms)	
8.2	Delta	kA (rms)	
8.3	All tap-offs	kA (rms)	
9	Bus conductor		
9.1	Material		Copper/ Aluminium
9.2	Maximum temperature rise of bus conductor joints over design ambient temperature of 500 C	°C	Bolted joints (plain/tinned) – 40°C Bolted joints (silver plated) – 55°C Aluminium welded joints – 55°C
10	Bus enclosure		
10.1	Type		Continuous/ Non continuous
10.2	Bus enclosure material		Aluminium alloy/ copper
10.3	Maximum temperature rise of bus enclosure & covers over design ambient temperature of 50°C	°C	Accessible surface – 20°C Inaccessible surface – 40°C
11	Purchaser's earthing conductor size and material		
12	Finish of bus enclosure (exterior)		
13	Layout drawing reference no.		
14	Bus duct quantities		
14.1	Bus duct lengths		

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Sl. No.	Items	Units	Design Particulars
i)	Main run (3 ph)	m	
ii)	Delta run (1 ph)	m	
iii)	Common tap-off to UATs (3 ph)	m	
iv)	Tap-off to UATs (3 ph)	m	
v)	Tap-off to VT & SP cubicles (3 ph)	m	
vi)	Tap-off to rect. Transformer (3 ph)	m	
vii)	Lead to NGR cubicle (1 ph)	m	
viii)	Tap-off to CLR (3ph)	m	
ix)	Tap-off to Brake switch (3 ph)	m	
14.2	Links		
i)	Disconnecting links		
a)	Location / Quantity		As per SLD
b)	Rated current under site conditions	A	To suit corresponding bus rating
ii)	Shorting links		
a)	Location / Quantity		As per SLD
b)	Rated current under site conditions	A	To suit Main bus rating
14.3	Flexibles		
i)	Location / Quantity		Refer write up / Layout / *
ii)	Rated current under site conditions	A	To suit corresponding bus rating
14.4	Bellows		
i)	Location / Quantity		Refer write up / Layout / *
14.5	Bends		
i)	Type/Quantity		
14.6	Wall frame assembly		
i)	Quantity	Nos.	
14.7	Tee-off connection		
i)	Rating / Quantity		Refer layout
14.8	Generator Adopter box along with associated components such as busbars, flexibles (if required), insulators, phase barriers etc.		
i)	Quantity	Nos.	
15	Insulators And Seal-Off Bushings		
15.1	Voltage class	kV (rms)	
15.2	One minute power frequency withstand voltage	kV (rms)	
15.3	Power frequency puncture withstand voltage	kV (rms)	
15.4	Impulse withstand voltage (1.2 x 50 micro sec. wave)	kV (Peak)	
15.5	Minimum total creepage distance	mm/kV	
15.6	Location of Seal-off bushings/ Quantity		As per layout

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Sl. No.	Items	Units	Design Particulars
16	VOLTAGE TRANSFORMER / SURGE PROTECTION		Details refer SLD, (if applicable)
16.1	Voltage Transformer		
i)	Quantity	Nos.	
ii)	Type		
iii)	Rated voltage		
a)	Primary	kV	
b)	Secondary S1	V	
c)	Secondary S2	V	
iv)	Rated burden of each secondary	VA	
v)	Accuracy class		
vi)	Method of connection		
a)	Primary		
b)	Secondary S1		
c)	Secondary S2		
vii)	Rated voltage factor		1.2 continuous & 1.9 for 8 hrs
ix)	Winding insulation class		
x)	Withstand test voltage for		
a)	HV Winding :		
b)	One min. power frequency withstand voltage1.2 x 50 micro sec impulse withstand voltage	kV (rms) kV (peak)	
16.2	HV Fuse		
i)	Quantity	Nos.	
ii)	Voltage class	kV	
iii)	Rated current	A	
iv)	Symmetrical fault interrupting capacity at rated voltage	kA	
v)	Peak short circuit current	kA	
16.3	Lightning Arrester		
i)	Quantity	Nos.	
ii)	Type		
iii)	Rated voltage	kV (rms)	
iv)	Maximum continuous operating voltage	kV (rms)	
v)	Frequency	Hz	
vi)	Nominal discharge current	kA	

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Sl. No.	Items	Units	Design Particulars
vii)	Residual voltage at nominal discharge current	kV (Peak)	
viii)	Temporary overvoltage capability	kV (rms) sec.	
ix)	One minute power frequency withstand voltage for housing	kV (rms)	
x)	1.2x50 micro-sec. impulse withstand voltage for housing	kV (Peak)	
xi)	Energy capability	kJ/kV	
xii)	Lightning arrester to suit the generator with BIL of kV	kV	
16.4	Surge Capacitor		
i)	Quantity	Nos.	
ii)	Type		
iii)	Voltage rating	kV	
iv)	Capacitance	µF	
16.5	General		
i)	VT & SP cubicles layout drawing no.		
ii)	Finish (exterior)		
iii)	Degree of protection		
17	GENERATOR NEUTRAL EARTHING CUBICLE		
17.1	Neutral Earthing Transformer		
i)	Type		
ii)	No. of phases and frequency		
iii)	Rated primary voltage	kV	
iv)	Rated secondary voltage	V	
v)	Secondary loading resistance	Ω	
vi)	Material of winding		
vii)	Winding insulation class		
viii)	Rated output of transformer		
a)	Continuous rating	kVA	

Sl. No.	Items	Units	Design Particulars
b)	1 Minute short time rating	kVA	
ix)	BIL of primary winding	kVp	
x)	One minute PF withstand voltage of HV/ LV	kVrms	
xi)	Max. permissible temperature rise over design ambient temperature	Deg.C	
xii)	Type of cooling		
xiii)	Continuously rated / short time rated (1minute) current	A	
xiv)	Taps	%	
17.2	Neutral Earthing Resistor		
i)	Duration of fault current	Sec.	
ii)	Continuously rated / short time rated	A	
iii)	Rated voltage	V	
iv)	Frequency	Hz	
v)	Taps	%	
vi)	Material		Stainless steel
vii)	Resistance	Ohms	
viii)	Allowable Temperature rise above design ambient of 50°C	Deg.C	750
17.3	Neutral Earthing Reactor		
i)	Continuously rated / short time rated	kVAR	
ii)	Voltage	V	
iii)	Frequency	Hz	
iv)	Taps	%	
v)	Coil inductance	mH	
vi)	Type of core		
vii)	Winding insulation class		
viii)	Material of winding		
ix)	Method of cooling		
x)	Allowable Temperature Rise	Deg.C	

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Sl. No.	Items	Units	Design Particulars
17.4	General		
i)	Finish (exterior)		
ii)	Degree of protection		
iii)	CTs on secondary side of NGT for 100% Stator Earth Fault		Required /Not Required
18	COOLING		
18.1	Type of forced air cooling system		Once through type/Recirculation type
18.2	Type of heat exchanger		Air to air/Air to water
18.3	Maximum inlet temperature of cooling water	Deg.C	
18.4	Inlet pressure of cooling water	kg/ sq.cm	
18.5	Number of heat exchangers		
18.6	Number of blowers		2 x 100%
19	PRESSURISATION EQUIPMENT		
19.1	Pressure of supply air	Mpa	
19.2	Pressure to be maintained inside bus ducts	Mpa	
19.3	Guaranteed leakage rate	%	<5%
20	CURRENT TRANSFORMER GENERAL CHARACTERISTICS		
20.1	Rated voltage class	kV	
20.2	Short time current rating	kA/ Sec	
20.3	Dynamic rating	kA	
20.4	Insulation class		
21	CURRENT TRANSFORMER RATINGS		
21.1	Generator Line side CTs		
i)	Quantity	Nos.	
ii)	No. of cores per phase		
iii)	Type		

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Sl. No.	Items	Units	Design Particulars
iv)	CT ratio (for each core)	A	
v)	Accuracy class		
vi)	Minimum knee point voltage (Vkp)	V	
vii)	Maximum secondary resistance	Ohm	
viii)	Rated burden	VA	
ix)	Application : Protection/metering		
x)	Maximum excitation current	mA	
xi)	ISF		
21.2	Generator Neutral side CTs		
i)	Quantity	Nos.	
ii)	No. of cores per phase		
iii)	Type		
iv)	CT ratio (for each core)		
v)	Accuracy class		
vi)	Minimum knee point voltage (Vkp)	V	
vii)	Maximum secondary resistance	Ohm	
viii)	Rated burden	VA	
ix)	Application : Protection/metering		
x)	Maximum excitation current	mA	
xi)	ISF		
21.3	Transformer (UAT/ SET /GT) Primary side CTs		
i)	Quantity	Nos.	
ii)	No. of cores per phase		
iii)	Type		
iv)	CT ratio (for each core)		

Sl. No.	Items	Units	Design Particulars
v)	Accuracy class		
vi)	Minimum knee point voltage (Vkp)	V	
vii)	Maximum secondary resistance	Ohm	
viii)	Rated burden	VA	
ix)	Application : Protection/metering		
x)	Maximum excitation current	mA	
xi)	ISF		
22	TESTS		
22.1	Type tests		
i)	One minute power frequency withstand voltage		Yes
ii)	Impulse withstand test		Type test report to be submitted
iii)	Temperature rise test on conductor and enclosure		Type test report to be submitted
iv)	Short time current test		Type test report to be submitted
v)	Dynamic current withstand test		Type test report to be submitted
vi)	Water tightness test		Type test report to be submitted
vii)	Air tightness test		Type test report to be submitted
22.2	Routine Tests		
i)	One minute power frequency withstand voltage test		Yes
ii)	Milli volt drop test		Yes
22.3	Performance test (at site)		
i)	One minute power frequency voltage withstand test		Yes
ii)	Water tightness test		Yes
iii)	Air tightness test		Yes
iv)	Functional checking of control circuits and interlocks		Yes
v)	Measurement of IR of control circuits		Yes

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Sl. No.	Items	Units	Design Particulars
vi)	Measurement of contact resistance on complete bus duct and on each tap off		Yes
vii)	Dye penetration test		Yes
viii)	Milli volt drop test		Yes
22.4	Test reports for the following components shall be submitted		Test reports for the following components shall be submitted during DDE
i)	Current transformers	Yes/no	Yes
ii)	Voltage transformers	Yes/no	Yes
iii)	Lightning arresters	Yes/no	Yes
iv)	Capacitors	Yes/no	Yes
v)	Insulators	Yes/no	Yes
vi)	Seal-off bushings	Yes/no	Yes
vii)	Neutral grounding transformer	Yes/no	Yes
viii)	Neutral grounding resistor/reactor	Yes/no	Yes
ix)	HRC fuses/ MCBs	Yes/no	Yes
x)	Conductor material	Yes/no	Yes
xi)	Enclosure material	Yes/no	Yes
xii)	Isolators	Yes/no	Yes
xiii)	Galvanising of support structures	Yes/no	Yes
xiv)	Heat exchangers	Yes/no	Yes
xv)	Bus duct cooling, pressurisation and hot air blowing equipment	Yes/no	Yes



7.9 Applicable Standards

Sl. No.	Description	Standard
1	Bus duct	IS 8084, BS 159, IEC, IEEE C37.23
2	Aluminium alloy bus bars	IS 5082, BSEN 755, IEC
3	Voltage transformers	IS 16227-3, IEC 61869-3
4	Current transformers	IS 2705, IEC 61869-2
5	Lightning arrester	IS 15086-4, IEC -60099-4
6	Insulators	IS 16683, BS 3297, IEC 60815
7	Bushings	IS/IEC 60137, BSEN 60137, IEC 60137
8	Fuses	BS 2692, IEC 60282, IS 9385
9	Neutral earthing transformers	IS 2026-6, IEC60076-6
10	Reactors	IS 2026-6, BSEN 60076-6, IEC 60076-6
11	Capacitors	IS 11548
12	AC metal enclosed switch-gear/control gear-1 kV upto and including 52 kV	IS/IEC 62271-200,BSEN 62271, IEC 62271-200
13	Water/air tightness test	IS 8084, USAS C-37-2C
14	Degree of protection	IS/IEC 60529, BSEN 60529, IEC 60529
15	Structural steel (standard quality)	IS 2062
16	Hot dip galvanising	IS 2629. BS EN ISO 1461, IS 2633
17	Code of practice for phosphating of iron & steel	IS 6005, BS EN 12476
18	Codes for welding	ASME, USAS
	NOTES	
	Equipment, accessories, component parts, raw materials & tests shall in general conform to	IS & IEC

CHAPTER 8: GENERATOR TRANSFORMER

8.1 Scope of Work

This Specification covers the requirements of sizing, design, engineering, material selection, constructional features, manufacture, inspection and testing at the VENDOR'S or his SUB-VENDOR'S Works, delivery to Site including transit insurance, installation, testing & commissioning and performance testing of of oil filled Transformers along with training of employer's personals.

8.2 Codes & Standards

The design, material, construction, manufacture, inspection, testing and performance of equipment shall comply with all currently applicable standards, codes of practice, regulations and safety codes in the locality where the equipment will be supplied & installed. Nothing in this specification shall be construed to relieve the CONTRACTOR of this responsibility.

The codes and standards mentioned in the various specifications and requirements specified in the enquiry document shall be latest as on the day of award of contract of the works unless otherwise specified. Contractor shall be responsible to inform to the Consultant/ Owner in case of any revisions/re-affirm/amendment in the relevant codes and standards after the date of award of contract within 30 days of the issue of such revision/re-affirm/amendment of the code/ standard. Consultant/ Owner may approve use of the earlier code/ standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed.

The power transformers (Generator Transformer, Unit auxiliary transformers, Station transformers) shall comply with latest versions of relevant Indian Standard or International Electrotechnical Commission Standards;

In case of conflict between the applicable standards and this specification, the more stringent of the two shall govern.

8.3 Design Criteria

The following list of transformers are covered under is specification. Rating of transformer, refer respective data sheet-A & SLD.

i) Generator Transformer (63 MVA, 13.8/400kV, 1-Ph, 13 No.)

ii) Interconnecting Transformer (ICT) (67 MVA, 132/400kV, 1-Ph, 4 No.)

iii) Shunt Reactor (8 MVAR, 400, 1 No.)

Ten percent extra oil in addition to that required for first filling of all transformers in non-returnable drums.

Foundation bolts and hardware, mounting channel and support structures for cooler control cabinets, coolers, marshalling boxes, pumps, fans etc. are included in BIDDER's scope and same shall be galvanised. The BIDDER shall also supply clamping device with nuts, bolts, and washers for clamping the transformers to the foundation.

8.4 General Constructional Features

i) All material used shall be of best quality and of the class most suitable for working under the conditions specified and shall withstand the variations of temperature and atmospheric conditions without distortion or deterioration or the setting up of undue stresses in any part, and also without affecting the strength and suitability of the various parts for the work which they have to perform.

ii) Similar parts, particularly removable ones, shall be interchangeable.

iii) Pipes and pipe fittings, screws, studs, nuts and bolts used for external connections shall be as per the relevant standards. Steel bolts and nuts exposed to atmosphere shall be hot dip galvanised.

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iv) Nuts, bolts and pins used inside the transformers and tap changer compartments shall be provided with lock washers or locknuts.

v) Exposed parts shall not leave pockets where water can collect.

vi) Internal design of transformer shall ensure that air is not trapped in any location.

vii) Materials in contact with oil shall be such as not to contribute to the formation of acid in oil. Surface in contact with oil shall not be galvanised or cadmium plated.

viii) Labels, indelibly marked, shall be provided for all identifiable accessories like relays, switches, fans, current transformers etc. All label plates shall be of in-corrodible material.

ix) All internal connections and fastenings shall be capable of operating under overloads and over excitation allowed as per specified standards without injury.

8.5 Cleaning, Painting and Tropicalisation

All steel surfaces except galvanized surfaces or where otherwise specified, shall be shot blasted to remove all rust, scale and foreign matters from the surface. Oil, grease, dirt and swarf shall be thoroughly removed by emulsion cleaning. The surfaces shall then be chemically cleaned, and surface treated by phosphating and dried in accordance with relevant standards. Immediately after phosphating, the surfaces shall be given two coats of high-quality zinc chromate primer.

The interior surfaces of mechanism chambers, boxes and kiosks, after preparation, cleaning and priming shall be painted with one coat of zinc chromate primer, one coat of phenolic based undercoating, followed by two coats of phenolic based finishing paint to white colour, followed by a final coat of anti-condensation (Specify color code RAL 7035). A minimum overall paint film thickness of 200 microns shall be maintained throughout.

All steel work and metal work, after preparation and priming shall be painted with one coat zinc chromate primer, one coat of phenolic based under coating and two coats of micaceous iron oxide paint to an overall thickness of 200 microns to hard glossy finishing of Shade as specified in Data Sheet A.

8.6 Electrical & Performance Requirements

Transformers shall operate without injurious heating at the rated MVA/MVAR at any voltage within ±10 percent of the rated voltage of that particular tap.

Transformers shall be capable of delivering the rated current at a voltage equal to 105 percent of the rated voltage without exceeding the limiting temperature rise.

Transformer for two or more limits of voltage or frequency or both shall deliver its rated KVA under all the rated conditions of voltage or frequency or both; provided an increase in voltage is not accompanied by a decrease in frequency.

The total harmonic content in the phase current of a star connected reactor and zero sequence components appearing in the neutral shall be below 3% of the crest value of fundamental when reactor is energised at rated voltage with sinusoidal wave form.

The noise level, when measured in accordance with relevant IEC shall not exceed the limits specified in NEMA standard.

The transformer shall have partial discharge level less than 100pC when tested at 1.5 Um/√3 kV rms.

The transformers shall be designed for the following over fluxing withstand capability:

i) 110% - Continuous

ii) 125% - For 1 minute

iii) 140% - For 5 seconds

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Transformers shall operate below the knee of the saturation curve at 110 percent voltage to prevent Ferro-resonance and non-linear oscillations.

All transformers shall be capable of operation continuously, in accordance with the applicable standard loading guide.

As the reactor shall be in constant operation, the total loss in the reactor shall be treated for capitalisation purpose, in the same way as the core loss of the transformer. Therefore, this loss shall be kept to a minimum. The reactor shall be subject to switching surge over voltage upto 2.5 p.u. and temporary over voltage for few cycles of the order of 2.3 p.u. followed by power frequency over voltage upto 1.5 p.u. The reactor must withstand the stress due to above transient dynamic conditions which may cause additional current flow as a result of changed saturation characteristics/slope beyond 1.5 p.u.

Transformers provided with mixed cooling shall comply as regards rating, temperature rise and overloads, with the appropriate requirements of applicable standard when operating with natural cooling and with mixed cooling. These transformers shall be capable of operating under the natural cooled condition up to the specified load. The forced cooling equipment shall come into operation by preset contacts in winding temperature indicator and the transformer will operate as a forced cooled unit. The manufacturer shall set the controls to operate at the recommended temperature. . Bidder shall state on the test report the actual temperature settings which have been adopted.

Overloads shall be allowed within the conditions defined in the loading guide of the applicable standard. Under these conditions, no limitations by terminal bushings, on-load tap changers or other auxiliary equipment shall apply.

Full power tapings shall be provided for the transformer.

The transformer shall withstand the short circuit at its terminals for the specified fault levels (mention fault value) for minimum duration of 3 seconds.

Starting from hot condition, transformers shall be capable of remaining in operation for following conditions without injurious heating, after failure of forced cooling:

i) At full load for not less than 10 minutes, after outage of all forced cooling.

ii) Transformers fitted with two coolers each capable of dissipating 50 percent of the losses shall be capable of remaining in operation at full load for not less than 20minutes in the event of failure of all forced cooling associated with one cooler.

Transformers, complete with bushings / cable boxes, shall be designed and constructed to withstand without damage, the effects of external short circuits as per the specified standards. Account shall be taken of the different forms of system faults that can arise in service, such as line to earth faults and line to line faults associated with the relevant system and transformer earthing conditions. The short circuit levels are specified by the PURCHASER in this specification and in the Single Line Diagram enclosed.

The thermal ability to withstand short circuit shall be demonstrated by the VENDOR by calculations.

The dynamic ability to withstand short circuit shall be demonstrated by tests or by reference to tests on similar transformers.

Every care shall be taken to ensure that the design and manufacture of all transformers shall be such as to reduce noise and vibration as per applicable standards

The transformers shall be designed with particular attention to the suppression of harmonic voltage, especially the third and fifth, so as to eliminate wave form distortion and from any possibility of high frequency disturbances reaching such a magnitude as to cause interference with communication circuits.

All rated quantities subject to the BIDDER’s guarantees shall be within the tolerances given in applicable standards.

Polarity for single phase transformers shall be subtractive.

To facilitate easy un-tanking of transformer / maintenance of equipment during overhaul, local marshalling boxes shall be so located as to require minimum disconnection during equipment maintenance / movement.

All bushing CT's as required shall be provided. BIDDER shall submit CT sizing calculations for all the CTs, which shall be subject to PURCHASER / ENGINEER's approval.

The under carriage of all the transformers shall be provided with detachable steel flanged wheels. Flanged wheels shall be spaced to allow standard rail gauge. Wheels shall be provided with suitable bearings(rollers) which will are resistant to rust and corrosion and shall be equipped with fittings for lubrications. It shall be possible to swivel the wheels or rollers in two directions, at right angles to or parallel to the main axis of the transformer, thereby permitting movement of the transformers in two directions. The wheels or rollers will be swivelled after jacking the transformer and they shall be lockable in the two positions. The CONRACTOR shall supply GT rails.

8.7 Core

i) The magnetic circuit shall be constructed from high grade cold rolled non-ageing grain-oriented silicon steel laminations having high permeability and low hysteresis loss.

ii) The reactors shall be either gapped core type or magnetically shielded air core type construction in three phase banks, Winding connections star type.

iii) Special measures shall be taken to combat the effects of stray/leakage flux.

iv) The gapped core shall be made up of radially laminated core packets.

The core packets consisting of magnetic laminations shall be bolted together by heavy rods jointly with ceramic spacers which make up the air gap.

v) A magnetic shield shall be provided around the coreless coils. Non-magnetic material sheet shall form the central core to minimize the vibrations. The magnetic circuit shall be constructed from high grade, cold rolled non-ageing, super grain-oriented silicon steel laminations. Core shall have magnetization characteristics with slope of the characteristics in the saturated region maintained between 0.3 to 0.5.

vi) The construction is to be of 'core' type.

vii) The supporting framework of core shall be so designed so as to avoid presence of pockets, which would prevent complete emptying of the tank through drain valve or cause trapping of air during oil filling.

viii) The laminations shall be free of all burrs and sharp projections. Each sheet shall have an insulating coating resistant to the action of hot oil.

ix) The insulation structure for the core to bolts and core to clamp plates shall be such as to withstand a voltage of 2500V for one minute.

x) The completed core and coil assembly of core type units shall be so assembled that the axis and the plane of the outer surface of the coil stack shall not deviate from the vertical plane by more than 25mm.

xi) All steel sections used for supporting the core shall be thoroughly shot or sand blasted, after cutting drilling and welding`.

xii) The finally assembled core with all the clamping structures shall be free from deformation and shall not vibrate during operation.

xiii) The core, frame, and tank (CFT) insulation shall be rated for 10 kV level.

xiv) The core clamping structure shall be designed to minimise eddy current loss.

xv) Oil ducts shall be provided where necessary to ensure adequate cooling.

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xvi) The core shall be provided with lugs suitable for lifting the complete core and coil assembly.

xvii) The core and coil assembly shall be so fixed in the tank that shifting will not occur during transport or short circuits.

xviii) The framework and clamping arrangements shall be securely earthed.

8.8 Internal Earthing

All internal metal parts of the transformer, apart from individual laminations, core bolts and their individual clamping plates shall be earthed.

The top clamping structure shall be connected to the tank by a copper strap. The bottom clamping structure shall be earthed by one or more of the following methods:

i) By connection through vertical tie rods to the top structure.

ii) By direct metal to metal contact with the tank base.

iii) By a connection to the top structure on the same side of the core as the main earth connection to the tank.

The grounding lead from the core shall be brought out of the tank through 11 kV class bushing and grounded externally. A protective cover shall be provided for the bushing.

When the magnetic circuit is sub divided by oil ducts or insulated barriers above 0.25mm thick tinned copper strip bridging pieces shall be inserted to maintain electrical continuity between segments of core.

Coil clamping rings of metal at earth potential shall be connected to the adjacent core clamping structure on the same side as the main earth connection.

8.9 Windings

Windings shall be of electrolytic grade copper unless specifically approved by the PURCHASER. The conductors shall be transposed at sufficient intervals in order to minimise eddy currents and equalise the distribution of currents and temperatures along the windings.

Windings shall be subjected to a shrinking and seasoning process, so that no further shrinkage occurs during service. Adjustable devices shall be provided for taking up possible shrinkage in service.

Coils shall be supported at frequent intervals by means of wedge type insulation spacers permanently secured in place and arranged to ensure proper oil circulation. To ensure permanent tightness of winding assembly, the insulation spacers shall be dried and compressed at high pressure before use.

All low voltage windings for use in the circular coil concentric winding shall be wound on a preformed insulating cylinder for mechanical protection of the winding in handling and placing around the core.

Windings shall not contain sharp bends which might damage the insulation or produce high dielectric stresses. No strip conductor wound on edge shall have width exceeding six times the thickness.

Materials used in the insulation and assembly of the winding shall be insoluble, non-catalytic and chemically inactive in the hot transformer oil, and shall not soften or be otherwise affected under the operating conditions.

Varnish application on coil windings may be given only for mechanical protection and not for improvement in dielectric properties. In no case varnish or other adhesive shall be used which will seal the coil and prevent evacuation of air and moisture and impregnation by oil.

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All threaded connections shall be locked. Leads from the winding to the terminal board and bushings shall be rigidly supported to prevent injury from vibration. Guide tubes shall be used where practicable.

Any joint within the winding will be brazed but lead joints will be crimped using suitable crimping terminals.

Coil clamping rings shall be of steel or of a suitable insulating material.

Permanent current carrying joints in the windings and leads shall be welded or brazed. Clamping bolts for current carrying parts inside oil shall be made of oil resistant material which shall not be affected by acidity in the oil. Steel bolts, if used, shall be suitably treated.

The completed core and coil assembly shall be dried in vacuum/conventional method depending upon the BIDDERs/standard manufacturer practice (Justification document from the manufacturer shall be provided at no more than 0.5 mm of mercury absolute pressure and shall be immediately impregnated with oil after the drying process to ensure the elimination of air and moisture within the insulation. Vacuum may be applied in either vacuum over tank or in the transformer tank. Vapour phases dry out shall be preferred.

The tolerance for the winding resistance measurement for different phases but at same taps shall be limited to 0.5%.

The change in impedance values shall not exceed +5% of nominal impedance value as specified at all taps/links on HV/LV side.

Current density at rated load should not be more than 2.5 A / sq.mm.

GT Winding paper moisture shall be less than 0.5%.

8.10 Tank

The tank shall be of conventional type or depending upon the BIDDERs /standard practice. (Bell tank not recommended for large ratings)

Tank shall be made from good commercial grade low carbon steel and shall be of welded construction

Tank shall be designed to permit lifting, by crane or jacks of the complete transformer assembly filled with oil. Suitable lugs and bosses shall be provided for this purpose.

Tank together with radiators, coolers, conservator, bushings vessel and other fittings, shall be designed to withstand without permanent distortion the following conditions & as per applicable standards.

i) Full vacuum of 760 mm of Hg. for filling with oil by vacuum.

ii) Internal gas pressure of 0.35 kg/cm2 (5 lbs/sq.in) with oil at operating level.

The transformer top shall be provided with a detachable tank cover with a bolted flanged gasket joint. Lifting lugs shall be provided for removing the cover. The surface of the cover shall be suitably sloped so that it does not retain rain water.

Manholes with bolted covers shall be provided in the top or sides of transformer for easy access to the lower ends of bushings, tap changers and to permit replacement of auxiliaries without removing tank cover.

Adequate space shall be provided at the bottom of the tank for collection of sediment.

The transformer base shall be designed to permit skidding of the complete transformer unit in any direction. The under base shall be detachable unless transport facilities permit a fixed base. Pulling eyes shall be provided for moving the transformer in either direction.

Necessary measures shall be adopted like increased clearances and separate aluminium shields to minimise eddy current losses in large capacity and high impedance transformers.

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The material used for gaskets shall be cork-neoprene or approved equivalent. Gasketed joints for tank and manhole covers, bushings and other bolted attachments shall be so designed that the gasket will not be exposed to the weather. Spare gaskets shall be provided for all openings as the gaskets used during shipping will not be reused.

Tank shall be provided with all necessary valves as specified.

Tank shall be provided with a pressure release device which shall operate at a pressure below the test pressure for the tank and radiators. The device shall be rain proof after blowing and shall be provided with a device visible from ground to indicate operation. This device shall be provided for all transformers. Pressure Relief Device shall be equipped with remote monitoring/alarm contacts.

The transformer shall also be furnished with the following non-corrodible plates, indelibly marked, showing:

i) Location and function of all valves and plugs and indication of the maintenance instrument reference for applying vacuum of drying and oil filling.

ii) Connection diagram

A ladder assembly shall be provided to reach the top of the transformer for maintenance work. It shall be possible to padlock the ladder to the transformer tank so that ladder cannot be removed. Usages of transformer structure/marshalling boxes etc as means to climb transformer are not acceptable.

Necessary arrangement (i.e barricading / suitable arrangement) on the top of transformer shall be provided to improve safety while working on transformer top.

8.11 Valves

Valves shall be of forged carbon/gun metal up to 50mm size and of gun metal or of cast iron bodies with gun metal fittings for sizes above 50mm. They shall be of full way type with screwed ends and shall be opened by turning counter clockwise when facing the hand wheel. There shall be no oil leakage when the valves are in closed position.

Every valve shall be provided with an indicator to show the open and closed positions and shall be provided with facility for padlocking in either open or closed position. All screwed valves shall be furnished with pipe plugs for protection.

All valves shall be provided with flanges having machined faces drilled to suit the applicable requirements. Oil tight blank flanges shall be provided for each connection for use when any radiator is detached and for all valves opening to atmosphere. If any special radiator valve tools are required, the BIDDER shall supply the same.

Each transformer shall be provided with following valves on the tank

Drain valve so located as to completely drain the tank. The sizes shall be as follows: a) 50 mm upto 10 MVA, b) 80 mm upto 40 MVA, c) 100 mm greater than 40 MVA,

i) Two filter valves on diagonally opposite corners, of 50 mm.

ii) Oil sampling valves not less than 8 mm, at top and bottom of main tank.

iii) One 15 mm air release plug.

iv) Valves between radiators and/or coolers as specified.

v) Two plugged pipe outlets for applying vacuum.

vi) All valves shall be suitable for continuous operation with transformer oil at 100° C.

Suitable valves shall be provided to take sample of oil from off-load tap changing chamber during Operation of the transformer

Oil sampling valves shall have provision to fix rubber hose of 10 mm size to facilitate oil sampling

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Additional pipe to be connected with the top filter valve and bring it down to a man accessible height i.e. 1.5 metre

8.12 Under Carriage

The under-carriage of the reactor/transformer shall be provided with detachable steel flanged wheels or flat rollers as specified in Data Sheet-A1. Flanged wheels shall be spaced to allow specified rail gauge. Wheels shall be provided with suitable bearings which will resist rust and corrosion and shall be equipped with fittings for lubrications. Unless otherwise approved, it shall be possible to swivel the wheels or rollers in two directions, at right angles to or parallel to the main axis of the reactor, thereby permitting movement in two directions. The wheels or rollers will be swivelled after jacking the reactor and they shall be lockable in the two positions.

8.13 Transformer Cooling Equipment

Radiators and coolers shall be designed to withstand the vacuum and pressure conditions specified for the tank. They shall be so designed as to avoid pockets in which moisture may collect, to completely drain oil into the tank and to prevent formation of gas pockets when the tank is being filled.

The clearance between all pipe work and live parts shall be more than the clearance for live parts to earth.

BUILT-ON RADIATORS (For Shunt Reactor)

The following accessories shall be provided for radiator:

i) Shut-off valves and blanking plates on reactor tank at each point of connection.

ii) Top and bottom shut-off valves and blanking plates on each radiator.

iii) Lifting Lugs

iv) Top oil filling plug, 19 mm size.

v) Air release plug at top

vi) Oil drain plug at bottom 19 mm size

8.14 Separately Mounted Radiators

Separately mounted radiator banks shall have bolted flanged connections and pipe extensions to permit withdrawal of reactor tank without disturbing the radiators. Flexible joints shall be provided in the interconnecting pipes (unless otherwise approved) to facilitate erection and dismantling and reduce transfer of vibrations from tank to radiator. The interconnecting pipes shall be provided with drain plug and air release vents. The following accessories shall be provided for each radiator bank:

i) Shut-off valves and blanking plates for reactor tank at each point of connection at the inlet and outlet header.

ii) Upper and lower shut-off valves and blanking plates for each group of radiators when radiators are assembled in groups.

iii) Lifting lugs, pulling eyes.

iv) Top and bottom oil filtering valves.

v) Air release plug at top.

vi) A drain valve at bottom, 25 mm size.

vii) A thermometer pocket with thermometer fitted with a captive screwed cap on the inlet and outlet pipes.

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8.15 Forced Oil - Forced Water Cooled Transformers

The cooling system shall comprise of two 100% capacity heat exchangers and two 100% capacity oil pumps.

The static head of oil shall always be greater than the inlet water pressure

The following minimum instrumentation shall be provided

i) Pressure gauges on oil and water inlet and outlet branches.

ii) An oil to water differential pressure gauge with alarm contact

iii) Visual oil and water flow indicators, each with one make and one break electrically separate contacts rated for minimum 0.5 A at 220V DC.

iv) Brass cases and guarded thermometers screwed in the inlet and outlet oil and water branches.

v) Plugged connections at the water inlet and outlet points of the heat exchanger to permit measurement of pressure drop through the exchanger by means of pressure gauges

The heat exchangers shall be suitably valved to permit maintenance outage of one unit with the other in service. A stop valve and a pressure reducing valve shall be provided at the water inlet of each heat exchanger. Suitable bleed valves for release of trapped air shall be provided. Drain valves shall be provided for draining out oil from the shell side and water from the tube side of the heat exchanger.

8.16 Oil Pumps

The oil pump and motor assembly shall be of the completely oil immersed glandless type. It shall be removable for maintenance without the need for lowering oil in the transformer or coolers and without disturbing pump foundation fixing. It shall be feasible to operate the transformer at its ON rating after removing oil pump and fitting suitable pipe extensions. Bleeding device shall be provided to ensure that air is not returned to the transformer when the oil pump is put back into service. Measures shall be taken to prevent mal-operation of Buchholz relay when all oil pumps are simultaneously put into service. Suitable baffles shall be provided inside the tank at oil inlet points when forced oil circulation is used

8.17 Motors

The motors shall be squirrel cage induction motor. The motors shall be suitable for a supply of 415V, 3 phase, 3 wire 50Hz.

Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following supply conditions as :

i)	Variation in supply voltage	from rated voltage	±10%
ii)	Variation in supply frequency	from rated frequency	±5%
iii)	Combined voltage and frequency variation		10%

Motors shall be suitable for Direct On Line (DOL) starting. The minimum permissible voltage shall be 85% of the rated voltage during motor starting.

Motors shall be capable of starting and accelerating the load with the applicable method of starting, without winding temperatures reaching injurious levels, when the supply voltage is in the range of 85% of the rated motor voltage to maximum permissible voltage specified.

The locked rotor current of the motor shall not exceed 600% of full load current (subject to tolerances as per the applicable standard).

Motors shall be capable of developing the rated full load torque even if the supply voltage drops to 70% of the rated voltage. If such operation is envisaged for a period of one second, the pull out torque of the motor shall be at least 205% of full load torque.

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Motors when started with the driven equipment coupled shall be capable of withstanding at least two successive starts from cold conditions & one start from hot condition without injurious heating of windings. The motors shall also be suitable for three equally spread starts per hour under the above referred supply conditions.

The class of insulation shall be Class-F with the temperature rise of the winding limited to Class-B.

Motors weighing more than 25kg shall be provided with eyebolts, lugs or other means to facilitate safe lifting.

i) The motor bearings shall not be subjected to any external thrust load.

ii) The bearings shall permit running of the motor in either direction of rotation.

iii) It shall be possible to lubricate the bearings without dismantling any part of the motor.

iv) Two independent earthing points shall be provided on opposite sides of the motor.

Motor shall be subjected to all the routine tests as per applicable standard. Copies of test certificates of type and routine tests shall be furnished as specified for PURCHASER'S approval.

8.18 Cooling System Control

All features and devices required for the cooler control scheme shall be supplied, mounted and wired up by the BIDDER.

Control equipment for the cooling system shall be mounted in a weatherproof marshalling box.

Control shall be suitable for both manual and automatic operation of each group of oil pumps.

Selector switches shall be provided for selection of pump equipment to be in 'service' or on 'standby'. A '3-position' (working-off-standby) switch shall be provided for each pumps. In the event of failure of any of the working pumps, the pumps chosen to be on standby mode shall automatically start. An annunciation and contacts for remote control shall be provided.

The BIDDER shall supply all necessary equipment for automatic changeover from 415V, 3 phase, 3 wire normal to standby incoming supply, in the event of failure of normal supply. Automatic transfer equipment shall include a 5 second time delay relay to prevent immediate transfer from the normal to emergency source. Facility for manual changeover should also be provided.

A magnetic contactor with thermal overload relays and MPCBs (motor protection circuit breakers) for short circuit protection shall be provided for each individual oil pump motor. Means shall be provided for isolating any oil pumps from the supply. Overload relays shall be hand reset type.

The following alarm initiating devices having normally open contacts shall be included, as applicable for the method of cooling:

i) Cooler power supply auto changeover

ii) Oil pump failure.

iii) Low oil flow for each pump

iv) Low water flow

The following initiating contacts for lamp indicators shall be included:

i) Oil pump start.

ii) Cooling system on automatic control

iii) Cooling system on manual control

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All contacts provided for alarm, tripping and indications shall be suitable for 220V DC ungrounded system. Each shall be electrically free and separately brought out to separate terminals. Necessary contacts shall be made available for remote indication / alarm in plant SCADA.

8.19 Insulating Oil

The quality of the oil, supplied with the transformer shall conform to relevant standards with latest amendment, if any. No inhibitors shall be used in the oil. The oil samples will be drawn as follows:

i) Prior to filling.

ii) Before and after heat run test.

iii) Before energising.

Sufficient quantity of oil, necessary for first filling of all tanks, coolers and radiators at the proper level along with 10% extra oil for topping up shall be supplied with each transformer in non-returnable containers, suitable for outdoor storage.

The transformer shall also be fitted with an impact recorder during transportation. This impact recorder is on returnable basis.

8.20 Tap Change Gear

8.20.1 Off-Circuit Tap Changing Gear

The off circuit tap changer shall be operable by means of an operating handle brought outside the tank and operable from ground level. It shall be equipped with an indicating device to show the tap in use and shall be provided with a locking arrangement to lock the switch in position. The tap changers contacts and connections shall be accessible through an access hole having a bolted gasketed cover.

8.21 Control Cabinets

The following applicable control cabinets shall be provided as applicable:

i) Marshalling box and

ii) Cooler control cabinet

These shall be either tank mounted or separately mounted.

Bottom shall be at least 600 mm from floor level. Top surface shall be sloped. Indicating lamps and meters shall be covered by a glass window. Gland plates and cable glands as required shall be provided at the bottom

All alarm and trip circuits shall be wired for auxiliary DC supply as specified.

Control cabinets shall be sheet steel enclosed and shall be dust, weather and vermin proof providing a degree of protection IP 55. Sheet Steel used shall be cold rolled and at least 2.0mm thick and properly braced to prevent wobbling.

Control cabinets shall be provided with hinged door(s) with padlocking arrangement and suitable brackets/channels shall be provided for the type of mounting specified.

All doors, removable covers and plates shall be gasketed all around with neoprene gaskets. All accessible live connections shall be shrouded and it shall be possible to change individual, switches, MCBs without danger of contact with live metal.

All live parts shall be provided with at least phase to phase and phase to earth clearances in air of 25mm and 20mm respectively.

Adequate interior cabling space and suitable removable cable glands shall be provided as required. Necessary number of cable glands shall be supplied and fitted screwed-on type and made of brass.

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Two earthing terminals shall be provided to suit the earthing conductor.

Contactor type motor starters shall be of the full voltage, direct-on-line, air break, single throw, electro-magnetic type unless otherwise specified. Automatic star-delta type starters shall be provided when specified.

MCBs / MPCBs / MCCBs shall be used and use of fuses shall be avoided.

Control and selector switches shall be of the rotary type provided with properly designated escutcheon plates clearly marked to show the operating positions. Control switches shall have momentary contacts, spring return to centre, with pistol grip handle. Selector switches shall have stay put contacts with oval handles. The number of contacts and their operation in each switch shall be as per the requirements of the connected circuit. The switches shall be rated for minimum 10A at 240V AC and 1A inductive break at 220V DC.

All pushbuttons shall be of push to actuate type having 2 'NO' and 2 'NC' self reset contacts. They shall be provided with integral escutcheon plates, engraved with their functions. Pushbuttons contacts shall be rated for 10A at 240V AC and 1A inductive breaking at 220V DC.

Indicating lamps of the Clustered Coloured LED type with coloured Lens engraved "ON","OFF","TRIP" shall be provided.

Strip type space heaters of adequate capacity shall be provided inside each cabinet. Heaters shall be complete with rotary type 'ON-OFF' switch, single-pole MCB with overload and short circuit protection, link on the neutral and a thermostat to cut off the heaters at 45ºCand shall have continuously settable range from 30ºC to 90ºC.

Control cabinet shall be provided with a 240V, 1 phase, 50 Hz, 40W preferably fluorescent lighting fixture for interior illumination controlled by a 'ON-OFF' switch / MCBs and 240V, 1 phase, 5/15A., 3 pin receptacle with Plug and Switch/MCB for Switching ON & OFF.

Control cabinet shall be supplied completely wired, ready for the external connections at the terminal blocks. All wiring shall be carried out with 650/1100V grade, PVC insulated, stranded conductors. Power circuits shall be wired with standard aluminium conductors of adequate sizes to suit the rated circuit current; the minimum size shall be 4Sq.mm. Control, alarm and indication circuits shall be wired with multi stranded copper conductors of sizes not smaller than 1.5Sq.mm. CT circuits shall be coloured wired for R Y B phases with multi stranded copper conductor of size, not smaller than 2.5Sq.mm.

Every equipment mounted in the cabinet shall be provided with individual labels with equipment designation/rating. Also, the cabinet shall be provided on the front & rear side with a non-rusting label engraved with the designation of the cabinet as furnished by the PURCHASER.

Control cabinet shall be subjected to following tests:

i) High voltage test (2000volts for 1minute)

ii) Megger test

iii) Electrical control, interlock and sequential operation tests

8.22 Bushings

All porcelain used in bushings shall be homogeneous, non porous, uniformly glazed to brown colour and free from blisters, burns and other defects.

Stresses due to expansion and contraction in any part of the bushing shall not lead to deteriorations.

Bushings shall be designed and tested to comply with the applicable standards specified in this specification.

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Liquid/oil filled bushings 36kV and above shall be equipped with liquid level indicators and means for sampling and draining the liquid. The angle of inclination to vertical shall not exceed 30o.

Oil in oil filled bushings shall meet the requirements of the transformer oil standards.

Bushings rated 72.5KV and above shall be of the oil filled condenser type with a central tube and draw in conductor which shall be connected to the connector housed in the helmet of the bushings. The pull through lead shall be fitted with a gas bubble deflector. For 145KV & above Resin Impregnated Paper (RIP) to be used.

Condenser type bushings shall be equipped with following:

i) Provision for power factor testing without disconnecting main leads. Bushings shall be provided for which no taps for potential device is provided.

ii) Bushings of 123kV and above shall have taps brought out for use with potential devices.

iii) Stress rings and lower end shields.

iv) Current transformers shall be provided, if specified and the bushing shall be so arranged that it can be removed without disturbing the current transformers and secondary terminals.

v) Bushing turrets shall be provided with vent pipes which shall be connected to route any gas collection through a Buchholz relay.

An alternate to Oil filled condenser type bushing, Resin Impregnated Paper (RIP) bushing can be used

Bushings rated for 400A and above shall have nonferrous flanges and hardware.

Fittings made of steel or malleable iron shall be galvanised. Bushing rated for 1000A and above shall have silver / tin plated palm.

Bushings shall be so located on the transformers that full flashover strength will be utilised and minimum clearances as required for the BIL shall be realised between live parts and live parts to earthed structures.

All applicable routine and type tests, as stated in the specified bushing standards shall be carried out. Also, following type tests shall be applicable for condenser type bushings:

i) Thermal stability test

ii) Measurement of partial discharge

iii) Power frequency withstand voltage test of voltage and test tappings insulation.

iv) Switching impulse withstand voltage test for bushings rated 300kV and above.

Bushings shall be supplied with terminal connector/clamp suitable for fixing to bushing terminal and the PURCHASER's specified conductors. The connector/clamp shall be rated to carry the bushing rated current without exceeding a temperature rise. The connector/clamp shall be designed to be corona free at the maximum rated line to ground voltage.

8.23 Bushing Current Transformers

Current transformers shall comply with specified standards. Bushing current transformer and quantities shall be furnished by the BIDDER as required with supporting calculations and subject to approval by the PURCHASER.

The core laminations shall be of high-grade silicon steel or other equivalent alloy.

It shall be possible to remove turret mounted CTs from the transformer tank, without removing the cover.

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All secondary leads, including tapings, shall be brought out through epoxy moulded common bushing block to a weather proof outlet box near the bushing. The BIDDER shall arrange conduit wiring from this outlet box up to the transformer marshalling box or control cabinet.

Bushing current transformer name plate shall be mounted on the equipment tank adjacent to the terminal box.

8.24 Cable Boxes and Disconnecting Chambers

When connection is by cables, unless otherwise approved, disconnecting chamber shall be provided for disconnecting and moving away the transformer without unsealing the cables or draining oil from the main tank, leaving the cable box or chamber behind on external supports. Arrangement to be provided for cable cleat installation.

Cable boxes and sealing ends shall be complete with jointing materials, compound and all other accessories including wiping glands, armour and earthing clamps.

The cable box shall have all standard facilities including fitting and drain plugs, relief vent, level glass and body earth terminal.

Cable boxes shall be designed to accommodate all cable joint fittings or sealing ends as required, including stress / cones or other approved means for grading voltage stress on the terminal insulation of cables operating at voltages of 22kV and above.

The disconnecting chamber shall preferably be air insulated. If oil insulated, the oil shall be segregated from transformer tank oil or cable box oil. Bushings, oil fitting and drain plugs, relief vent, level glass, removable links and removable covers shall be provided for the disconnecting chamber. Plates, through which high current carrying conductors pass, shall be non-magnetic unless otherwise approved by the PURCHASER.

Phase to phase and phase to ground clearances within the chamber shall be such as to enable either the transformer or each cable to be subjected separately to HV tests, when filled with transformer oil. Clearances shall be subject to the PURCHASER's approval. Insulating Fire resistant barriers should be provided between each phase of HV cable box.

8.25 Bus Duct Terminations

When bus duct termination is specified in Data Sheet, a flanged throat or equivalent connection shall be provided to suit PURCHASER's bus ducts. The winding terminations shall be on outdoor type of bushings. Necessary flexibles shall connect the bushing terminals to the bus bars. The material of the bus duct termination shall be non-magnetic unless otherwise approved by the PURCHASER.

8.26 Fittings and Accessories

8.26.1 The following Fittings and Accessories Shall Be Provided:

Earthing pads: Two earthing pads of copper or other non-corrodible material shall be welded at the bottom corners of the transformer tank and supplied with clamp type terminals suitable for the earthing conductors. Suitable earthing terminals on cable boxes and separately mounted radiator banks shall also be provided.

Neutral earthing bar of copper of suitable cross section shall be installed from the neutral bushing to ground level suitably supported along its run on porcelain insulators, together with clamping arrangements at neutral bushing and for two earth conductors. The supporting insulators shall be tank mounted.

Terminal marking and rating plates shall be as per the specified standard and also to give the following additional information:

i) Connection diagram showing the internal connections.

ii) Guaranteed Temperature rise of winding and oil.

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iii) Insulation levels of the windings, including neutral end of windings with uniform insulation.

iv) Transportation weight.

v) Un-tanking weight.

vi) Core and winding weight.

vii) Table giving the tapping voltage, tapping current and tapping power factor for each tap.

viii) Values of short circuit impedance on the extreme tappings and on the principal tapping and indication of the winding to which the impedance is related.

The transformer shall also be provided with the following non-corrodible plates, indelibly marked showing:

i) Location and function of all valves and plugs and indication of the maintenance instrument reference for applying vacuum drying and oil filling.

ii) Valves connection diagram

The conservator shall be of sufficient volume to maintain the oil seal from the minimum ambient temperature of – 5oC up to an oil temperature of 100oC, with oil level varying within the minimum and maximum visible levels. The conservator shall be provided with the following accessories:

i) Filling plug, sump and drain valve of 15mm size for conservator of size 650mm and 25mm size for conservator above 650mm diameter.

ii) 150mm diameter magnetic type oil level gauge with low oil level alarm contacts and provided with markings for minimum oil level and oil level at rated temperature rise.

iii) A bolted cover at one end for cleaning.

iv) Valve for shutting off oil to the transformers.

v) Weatherproof dehydrating breather with silica gel and oil seal to eliminate constant contact with the atmosphere, mounted at a level of about 1400mm above ground level.

vi) Non-return valve on both sides of Buchholz relay

vii) Conservator shall be equipped with aircell separator

Valves shall be supplied on the transformer tank, radiators and coolers.

Pressure relief device:

i) PRD shall automatically reset when pressure falls below the set value

ii) Contacts shall be provided for alarm and trip and initiation on operation of the device.

iii) One of the following methods shall be used for relieving or equalising the pressures in the pressure relief device:

a. An equaliser pipe connecting the pressure relief device to the conservator or

b. The fitting of silica gel breather to the pressure relief device, the breather being mounted in suitable position for access at ground level.

8.26.2 Gas and Oil Actuated Relay (Buchholz Relay)

A double float type Buchholz relay as per specified standard shall be provided for all oil filled transformers. All gas evolved in the transformer shall collect in this relay. The relay shall be provided with a test cock suitable for a flexible pipe connection for checking its operation. A 5mm copper pipe shall be connected from the relay test cock to a valve located about 1.25m above ground level to facilitate sampling with the transformer in service. The device shall be

provided with two electrically independent ungrounded contacts, one for alarm on gas accumulation and the other for tripping on sudden rise of pressure. These contacts shall be wired upto the transformer marshalling box. The relay shall be provided with shut off valves on the conservator side as well as the tank side.

8.27 Temperature Indicators

8.27.1 Dial Type Thermometer

All transformers shall be provided with a 150mm dial type thermometer for top oil temperature indication. The thermometer shall have adjustable, electrically independent ungrounded alarm and trip contacts, maximum reading pointer and resetting device. The contacts shall be rated minimum 0.5A making and 0.2A breaking at 220V DC.

Analog signal of OTI for providing the temperature readings on control room HMI shall be considered.

8.27.2 Winding Temperature Indicator

A device for measuring the hot spot temperature of the winding shall be provided. It shall comprise of the following :

i) Temperature sensing element.

ii) Image coil

iii) Current transformer

iv) 150mm dia local indicating instrument with four adjustable electrically independent ungrounded contacts, two for control of cooling equipment and two for winding temperature alarm and trip.

v) A pointer to register the highest temperature reached and capable of being reset without tools.

vi) Calibration device

vii) Automatic ambient temperature compensation.

viii) In addition to the above the following transducers shall be provided for remote indication.

a. Remote winding temperature indicator for each winding: - It shall be suitable for flush mounting on RTCC panel. The difference between local and remote WT indication at any given time shall not exceed 1 °C.

b. Top oil resistor temperature detector with output of 4 – 20 mA

c. Winding temperature detector for specified windings with output of 4 – 20 mA.

An alternate to conventional dial type WTI/OTI, Digital WTI/OTI can be provided.

Facility for remote temperature monitoring to be provided.

All contacts shall be rated minimum 0.5A making and 0.2A breaking at 220V DC. Connections shall be brought out from the device to terminals placed inside the marshalling box.

Anti-earthquake clamping device to keep the transformer from moving during an earthquake. The clamping device shall be suitable to be fixed to the foundation.

Oil preserving equipment of either of the following types shall be furnished for large generator transformers

i) Inert gas (nitrogen) pressure system - Gaseous nitrogen shall be sealed in the space above the oil level in the conservator or the tank. The system furnished shall be automatic in operation, shall provide for expansion and contraction of oil due to

variation in daily oil temperature without discharging gas and shall seal the interior from atmosphere. A separate nitrogen chamber may be provided if the conservator capacity is insufficient. Particular care shall be taken to eliminate gas leakage. A low gas pressure electric alarm device shall be supplied to be connected to the PURCHASER's remote annunciation.

ii) The system shall be complete with a gas cylinder filled with high pressure gas, an automatic reducing valve, a breathing regulator and a mechanical relief valve. A compound pressure gauge shall be provided for gas pressure indication (high pressure in cylinder and the working pressure, which can be regulated) and an instruction plate giving nitrogen pressure vs. maximum temperature of oil. A bracket for attaching block and tackle shall be provided to assist in removal of the gas cylinder.

iii) Sufficient gas for blowing out and displacing the air in the transformer shall be supplied in addition to the full initial supply of gas required for initial operation.

Sealed expansion tank type. A flexible oil resistant air bag shall be provided in the conservator to prevent the air from coming into contact with the oil. The air bag shall be designed to withstand repeated expansion and contraction due to changes in oil level. The conservator shall be furnished with all valves and accessories. A device shall be provided so that in the event that air enters the conservator as a result of rupture of the bag, an alarm sounds.

With nitrogen seal system, a sudden pressure relay shall be supplied with one set of 220V/48V DC alarm contacts on pressure switch. The contacts shall be wired up to the marshalling box (kiosk) terminals. The relay shall be connected to the nitrogen chamber and the relay shall function depending on the rate of change of pressure and should not operate on the normal pressure variations in the tank.

Suitable shock recorders to record maximum shock forces during shipment/ transport shall be provided.

A set of hydraulic jacks suitable for the transformers under supply.

8.28 Online Monitoring System

The on-line monitoring device shall combine in a single system and measure the following:

i) Gas contents in the insulating oils in the transformer main tank using photo-acoustic spectroscopy or NIR technology. The equipment shall measure each gas individually and give results in ppm. Moisture should also be measured in ppm.

The sensors shall be installed on three phase Transformer and shall be connected to one acquisition unit for monitoring.

The monitoring system shall be housed in a single IP56 acquisition box, wall or stand mounted, to be placed near the transformer.

The instrument shall be an Intelligent Electronic Device (IED), designed to continuously detect and measure dissolved Gases (9 gases) and Water content in Transformer Oil may be finalised during detail engineering. It should be easy to install on an energised transformer, without shutting down the transformer. The instrument shall be equipped with an inbuilt oil circulation system to ensure that the oil being sampled is the true representative sample of the oil from the transformer tank. The instrument shall have sufficient data storage capacity with Modbus TCPIP/IEC61850 compatible ports for communication with plant SCADA system.

Port with valve for measurement of dissolved gases through portable DGA test set

Continuous on-line moisture-in-oil and online dissolved gas analyzer (9 gases) for indicating, monitoring, data acquisition and transmission of suitable status/alarm/trip signals to plant SCADA system,

Inputs to SCADA system for monitoring of transformer oil and winding temperature and hot spot temperature:

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i) For extinguishing

ii) Fire Detector

iii) Buchholz relay paralleled with pressure relief valve or RPRR (Rapid Pressure Rise Relay).

Fire protection walls shall be provided as per the guidelines of **Bureau of Indian Standards (**BIS).

The generator transformers shall be provided with online dissolved gas analyser system.

Dynamic short circuit withstand test shall be conducted on one unit of each type and rating of transformers, to validate the design and quality, unless such test has been successfully conducted as per IS 2026 part-5 within last 10 (ten) years on transformer of similar design. Criteria for similar design shall be as per Annexure- J of CEA's "Standard Specifications and Technical Parameters for Transformer and reactors (66kV and above)".

8.29 Soak Pit and Oil Collecting Pit:

An oil soak pit shall be designed & provided below each oil filled transformer or reactor to accommodate at least 150% of total quantity of oil contained in the transformer or reactor with minimum 300 mm thick layer of gravels or pebbles of approximately 40 mm size (spread over a steel iron grating or trans rack) providing free space below the grating.

Alternatively, an oil soak pit shall be provided below each transformer or reactor, to accommodate one-third of total quantity of oil contained in the transformer or reactor with minimum 300 mm thick layer of gravels or pebbles of approximately 40 mm size (spread over a steel iron grating or trans rack) providing free space below the grating provided a common remote oil collecting pit of capacity at least equal to oil quantity in the largest size transformer or reactor is provided for a group of transformers or reactors and bottom of the soak pit below the transformer or reactor shall be connected to the common remote oil collecting pit with drain pipe of minimum 150 mm diameter with suitable slope for fast draining of oil or water through gravity from soak pit to the common remote oil collecting pit.

Every soak pit below a transformer or reactor shall be designed to contain oil dropping from any part of the transformer or reactor.

The common remote oil collecting pit and soak pit (when remote oil collecting pit is not provided) shall be provided with automatic pumping facility, to always keep the pit empty and available for an emergency.

The disposal of transformer oil shall be carried out in an environmental friendly manner.

A transformer shall be physically checked and tested for its electrical and mechanical performance characteristics as per relevant IS before commissioning.

Transformer Health Monitoring system shall also be provided for monitoring the health of power Transformers.

A transformer shall be provided with two separate body earthing terminals which in turn shall be connected to two separate earth points, besides neutral earthing terminal.

8.30 Transformer Mounting Structure.

i) The mounting of transformers shall be as per relevant Indian Standards.

ii) The structures shall be provided with:

iii) Anti-climbing devices and

iv) Danger board.

v) The plinth shall be

vi) Higher than the surroundings.

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vii) made of Concrete or Metal (properly earthed) of adequate strength to withstand the load

8.31 Cubicle (FEC)

The Cubicle Frame shall be made of CRCA sheet of 3 mm (minimum) thick complete with the base frame, painted inside and outside with post office red colour (shade 538 of IS -5). It shall have hugged / hinged split doors fitted with high quality tamper proof lock. The doors, removable covers and panels shall be gasketed all round with neoprene gaskets. The degree of protection shall be IPW55.

8.32 Control Box

Control box is to be placed in the switchyard control room for monitoring system operation, automatic control and remote operation. The following alarms, indications, switches, push buttons, audio signal etc. shall be provided.

i) System Oil.

ii) TCIV open.

iii) Oil drain valve closed.

iv) Gas inlet valve closed.

v) TCIV closed.

vi) Detector trip

vii) Buchholz relay trip

viii) Oil drain valve open

ix) Extinction in progress

x) Cylinder pressure low

xi) Differential relay trip

xii) PRV / RPRR trip

xiii) Transformer / reactor trip

xiv) System out of service

xv) Fault in cable connecting fault detector

xvi) Fault in cable connecting differential relay

xvii) Fault in cable connecting Buchholz relay

xviii) Fault in cable connecting PRV / RPRR

xix) Fault in cable connecting transformer reactor trip

xx) Fault in cable connecting TCIV.

xxi) Auto / Manual / Off

xxii) Extinction release on / off

xxiii) Lamp test

xxiv) Visual / Audio alarm for AC supply fail

xxv) Visual / Audio alarm for DC supply fail As far as possible the control box should be such devised that all the transformers and reactors or group thereof should be controlled from single spot.

xxvi) Transformer Main tank and Conservator Isolation Valve:

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Transformer conservator isolation valve (TCIV) to be fitted in the conservator pipe line, between conservator and buchholz relay which shall operate for isolating the conservator during abnormal flow of oil due to rupture / explosion of tank or bursting of bushing. The valve shall not isolate conservator during normal flow of oil during filtration or filling or refilling, locking plates to be provided with handle for pad locking. It shall have proximity switch for remote alarm, indication with visual position indicator.

The TCIV should be of the best quality as malfunctioning of TCIV could lead to serious consequence. The closing of TCIV means stoppage of breathing of Transformer. Locking plates shall be provided for pad locking.

8.33 Detectors

The system shall be completing with adequate number of heat detectors fitted on the top cover of the Transformer oil tank. All the required Fire detectors shall be connected with signal box/control box.

8.34 Signal Box

It shall be mounted away from Transformer main tank, preferably near the marshaling box, for terminating cable connections from TCIV & detectors and for further connection to be control box. The degree of protection shall be IP65.

8.35 Cables

Fire survival cables (capable to withstand 750º C.) of 4 core x 1.5 sq. mm size for connection of detectors in parallel shall be used. The fire survival cable shall conform to BS 7629-1, BS 8434-1, BS 7629-1 and BS 5839-1, BS EN 50267-21 or relevant Indian standards.

Fire Retardant Low Smoke (FRLS) cable of adequate size shall be used for connection of signal box / marshalling box near transformer / reactor and FEC mounted near transformer/ reactor with control box mounted in control room.

Fire Retardant Low Smoke (FRLS) cable of 4 core x 1.5 sq. mm size shall be used for connection between control box to DC & AC supply source, FEC to AC supply source, signal box / marshalling box to transformer conservator isolation valve connection on transformer / reactor. Separate cables for AC supply & DC supply shall be used.

8.36 Pipes

Pipes complete with connections, flanges, bends and tees etc. shall be supplied along with the system.

8.36.1 Other items to be supplied.

i) Flanges between Buchholz relay and conservator tank for fixing TCIV.

ii) Detector brackets on Transformer tank top cover.

iii) Spare potential free contacts activating the system i.e. in differential relay, Bucholz relay. Pressure Relief Device / RPRR, Circuit breaker of Transformer.

iv) Pipe connections between Transformer and FEC and between FEC and oil pit required for collecting top oil.

v) Cabling for detectors mounted on Transformer top cover.

vi) Inter cabling between signal box, control box and FEC.

vii) Butterfly valves / Gate valves on oil drain pipe and which should be able to withstand full vacuum.

viii) Supports, signal box etc. which are to be painted with enamelled paint.

ix) Any other item required for satisfactory operation of system.

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x) All necessary Interface details of Control Box/Relay Panel are to be provided for interfacing with existing Master Fire Alarm Control Panel for the annunciation of the important Fire alarm signals in Central Control Room.

8.37 Power Supply

For Control Box 220 V DC and For FEC Auxiliary 230 V AC

8.38 Spares for Operation & Maintenance

The bidder apart from the below mentioned spares shall submit a list of recommendation spares for Five (5) years trouble free operation of the equipment's and also furnish unit rates. The owners will scrutinize the said list and decide on the items on spares to be ordered and the quantities. These spares shall be supplied by the Bidder before end of guarantee period. The owner reserves right to order the spares with twelve (12) months from the date of order for main equipment's and the rate shall be kept valid till this date. The prices of these spares shall not be considered for evaluation of the bid.

8.39 Mandatory Spares

Recommended spare parts shall be supplied in accordance to clause 3.0 "Spare Parts and Tools" of General Technical Specifications. Mandatory spare parts to be supplied under this Chapter are as detailed in Schedule –B.

i) Detectors per Transformer -3 No.

ii) Regulator assembly -1 No.

8.40 Tests

i) The list of type tests shall be as per relevant IS/IEC standards.

ii) All transformers shall be completely assembled at works to ascertain that all parts fit correctly.

iii) Routine Tests: Routine tests as per specified standards shall be performed on all transformers. The following additional points may be noted with respect to routine tests:

iv) Measurement of winding resistance at all taps.

v) Impedance voltage shall be measured at nominal and extreme taps.

vi) No load loss and exciting current shall be measured at rated frequency at 90%, 100% and 110% rated voltage.

vii) No load loss and exciting current shall be measured and recorded with 415V, 3-phase, 50 Hz. Input on LV side (assuming LV is rated higher than 415V).

viii) Power taken by cooling equipment shall be measured for all transformers and mentioned in the test report.

ix) Oil leakage test

x) Magnetic balance test for 3 phase units.

xi) HV test on magnetic circuit test as per applicable standard

xii) Pressure test on each size of pressure relief device as per applicable standard

xiii) CT tests viz. IR, ratio, polarity, excitation etc.

xiv) Calibration of temperature indicators and relays

xv) Measurement of zero sequence impedance

xvi) Measurement of tan delta and capacitance of each winding and bushing.

8.41 Special Tests

i) Zero sequence impedance measurement on three phase transformers

ii) Measurement of harmonics of the no load current

iii) Measurement of power taken by fans and oil pumps

iv) Short circuit withstand tests

v) Dielectric special tests

vi) Determination of capacitances windings-to-earth, and between windings

vii) Determination of transient voltage transfer characteristics

viii) Measurement of insulation resistance to earth of the windings, and/or measurement of dissipation factor (tan□) of the insulation system capacitances

ix) Determination of sound levels

x) Lightning impulse test on neutral terminal

xi) Long duration induced AC voltage test (ACLD) transformer winding Um<170kV

xii) Dissolved gas analysis before and after temperature rise test

xiii) Test with lightning impulse chopped on the tail

xiv) Magnetic balance test on three phase transformers

xv) Pressure test on tank and coolers

xvi) Vacuum test on tank and coolers

xvii) Noise level

xviii) Recurrent surge Oscillographic (RSO) test

xix) Determination of core hot spot temperature

xx) Sweep Frequency response analysis (SFRA) test

xxi) Measurement of magnetization current at low voltage

xxii) Functional test on auxiliary equipment

xxiii) No load current at 112.5% voltage

xxiv) Dew point measurement before dispatch

xxv) BDV and moisture content of the oil in the transformer

xxvi) Paint adhesion test

8.42 Mechanical Test

i) Oil pressure test on completely assembled transformer.

ii) Jacking test and dry penetration test

iii) Pressure relief device test

8.42.1 Type Tests:

Valid type test report (tested within five years) for the following tests shall be submitted for the similar type & rating transformer.

i) Temperature rise test

ii) Dissolved gas analysis of the oil, before and after the temperature rise test.

iii) Dielectric type tests

iv) Short circuit withstand test

v) Vacuum withstand test on tank and radiators / Pressure test

If type test is not specified to carry-out, Vendor shall submit the type test certificates for the similar rating and the test certificates shall not be older than 5 years or otherwise test shall be conducted by Vendor without additional cost.

All auxiliary equipment shall be tested as per the relevant standards. Test certificates shall be submitted for bought out items. High voltage withstand test shall be performed on auxiliary equipment and Wiring After Complete Assembly.

8.43 Test Reports

Test results shall be corrected to a reference temperature of 75oC.

Two copies of preliminary test results shall be submitted for the PURCHASER's approval before despatch of transformer.

BIDDER shall furnish detailed commissioning check lists along with procedures and formats for recording of the tests for all equipment for PURCHASER's review/approval.

8.44 Deputation of Engineers for witness of Tests, Inspection & Training

The Employer's representatives shall be deputed for the following purposes.

Sl. No.	Description	Batch	No of Days	No. of Engineers and Technicians
1	Training at the plant and design office	2	5	4 Engineers 6 Technicians
2	Shop Inspection and Test	As and when required for inspection and test		

Note: This training is inclusive of all transformers under the scope of this package.

The training of employer's personnel shall be as specified in clause 11.0 "Training of Employer's Personnel" of General Technical Specification.

8.45 Storage at Site

BIDDER shall indicate the specific requirements, if any for proper storage of the equipment supplied at site.

In general, while shipping the equipment to site, BIDDER shall ensure that each assembly or component shall be crated, boxed or otherwise suitably protected against damage or loss during shipment and to facilitate site storage. All openings shall be effectively sealed with temporary closures to prevent entry of dust, dirt, moisture and other foreign matter.

8.46 Performance Guarantee

The Generator Transformers along with ICT and all auxiliaries and accessories shall be capable of performing intended duties under specified conditions. The contractor shall guarantee the reliability and performance of the individual equipment as well as of the complete system.

8.47 Guaranteed losses

The no load losses in kilowatts at rated voltage and rated frequency, load losses and total loss in kilowatts at rated output, rated voltage and rated frequency shall be guaranteed.

8.48 Bid Evaluation

Bids will be evaluated based on the formula for capitalization of losses furnished in datasheet.

The quoted load losses and iron losses shall be maximum including the applicable tolerances as per standards.

8.49 Liquidated damages for shortfall in losses

For losses in excess to the guaranteed values of iron losses, auxiliary losses, and copper losses, liquated damages shall be applicable at rates given below:

i) No Load loss per KW – INR/BTN 0.22Million

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ii) Auxiliary losses per KW – INR/BTN 0.22Million

iii) Copper loss per KW - INR/BTN 0.22Million

For the purpose of computations of liquidated damages, the tests figures of the no load, auxiliary losses and copper losses will be compared with the corresponding guaranteed figures.

The liquidated damages shall be separately evaluated from:

i) The excess of the test values of the no load loss and auxiliary loss in kW over the corresponding guaranteed values.

ii) Excess of the difference between the test values of the total loss and no-load loss plus auxiliary loss in kW over the differences of the corresponding guaranteed values.

No tolerance shall be permitted over the test values of the losses. For fraction of a kW, the liquidated damages shall be applied pro-rata. If the test values of the losses are less than the guaranteed values, no bonus will be given. The losses shall be computed for all the transformers. The maximum loss figure of all the transformers shall be multiplied by the number of transformers for the calculation of gross liquidated damages.

No load tests shall be performed both before and after the impulse tests. If the variation is more than 15% between the test values, the tested transformer will be rejected. Test figure of no-load loss after impulse tests shall be considered for purpose of liquidated damage provided variation remains within or equal to 15% of test figure measure before impulse tests.

The Employer reserves the right to reject any transformer, if during tests at works; any individual loss (Iron Loss, Cu Loss and Auxiliary loss) exceeds the guaranteed values by more than 15% individually. However, the total losses (Iron Loss, Cu Loss and Auxiliary Loss) should not exceed by more than 10% of the guaranteed values.

The figure of no-load loss, auxiliary loss and copper loss for equalisation of bid during bid evaluation are separately mentioned in the ITB of the contract document.

8.50 Rejection

8.50.1 The PURCHASER may reject any transformer if during tests or service any of the following conditions arise:

i) No load loss exceeds the guaranteed value.

ii) Load loss exceeds the guaranteed value.

iii) Impedance value exceeds the guaranteed value of ± 10% or more.

8.50.2 The difference in impedance values of any two phases during single-phase short circuit impedance test exceeds 2 percent of the average value guaranteed by the VENDOR.

i) Oil or winding temperature rise exceeds the guaranteed value.

ii) Transformer fails on impulse test.

iii) Transformer fails on power frequency voltage withstand test.

Transformer is proved to have been manufactured not in accordance with the agreed specification.

The PURCHASER reserves the right to retain the rejected transformer and take it into service until the VENDOR replaces, at no extra cost to the PURCHASER, the defective transformer by a new transformer.

Alternatively, the VENDOR shall repair or replace the transformer within a reasonable period to the PURCHASER's satisfaction at no extra cost to the PURCHASER.

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8.51 Safety Requirements

8.51.1 Electrical and Mechanical safety by design:

i) Bidder to design the transformer as per the technical parameter listed in the specification.

ii) Bidder to ensure safety of the equipment by carrying out all the routine, type and special test mentioned in the specification.

iii) Bidder to design the transformer and source bought item as per IS and IEC standards and CBIP guidelines.

8.51.2 People safety by design:

Bidder to consider safety railing on transformer tank, ladders at appropriate location and safety platform for accessing transformer devices safely as mentioned in the specification.

All the Marshalling boxes shall be mounted considering safe working access.

8.52 Employer's Specifications for GT

Sl. No	Description	Unit	Client's Specification
1.0	**General**		
1.1.	Application/Designation		**Generator Transformer**
1.2.	Quantity		63 MVA, 1 Phase, 13.8kV/400 kV Total = (4x3) +1= 13 Nos.
1.3.	Installation	Indoor/ Outdoor	Outdoor type
1.4.	Type	2-Winding / 3-Winding	2 – Winding
1.5.	Three Phase / Single Phase Unit		1-Phase
1.6.	Rating of each Winding		
i)	HV Winding	MVA	3x63 MVA
ii)	LV Winding	MVA	3x63 MVA
1.7.	Type of Cooling		OFWF
1.8.	Cooler Bank Arrangement		5 X 25%
1.9.	Efficiency		>99%
2.0	**Ratings**		
2.1.	No load voltage		
i)	(a) LV Winding	kV	13.8
ii)	(b) HV Winding	kV	400
2.2.	Frequency	Hz	50
2.3.	Rating for each type of cooling		Rating for each type of cooling
2.4.	Percentage impedance at 75°C	%	≥12.5 (with IS tolerance)
3.0	**CORE**		
3.1.	Over fluxing		1.10 - CONTINUOUS 1.25 - 1 MINUTE 1.40 - 5 SEC 1.50 - 2 SEC
4.0	Maximum Flux Density		At rated voltage 1.7 Wb/m2 At 110% rated voltage 1.9 Wb/m2
5.0	Current Density		HV 2.5 A/sq. mm LV 2.5A/sq. mm.

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Sl. No	Description	Unit	Client's Specification
6.0	Transformer External Short Circuit Withstand Capacity		GT shall be designed for bolted Short Circuit (SC) at its terminal (HV or LV) considering only self-percentage Impedance for 3 second thermal rating and dynamic rating as per IEC 60076.
7.0	**Winding Connections**		
7.1.	Winding Connection (Vector Group)		YNd11
7.2.	Direction of Power Flow		Bi-directional
8.0	**System Data**		
8.1.	System Voltage		
i)	HV – Nominal / Highest	kV / kV	400 / 420
ii)	LV – Nominal / Highest	kV / kV	13.8 / 17.5
9.0	Fault Level		
i)	LV system (primary)	kA	Refer SLD
ii)	HV system (secondary)	kA	Refer SLD
9.1.	System Neutral Earthing		
i)	Effectively Resonant Non-effectively Isolated	LV (primary)	Unearthed
		HV (secondary)	Solidly earthed
10.0	**Winding Insulation**		
i)	Uniformly insulated	LV (primary)	Uniformly insulated
ii)	Non-uniformly insulated	HV (secondary)	Non-Uniformly insulated
11.0	**Transformer Neutral**		
i)	Type of earthing		
ii)	(a) Solidly earthed. (b) Non-effectively (c) Isolated / Unearthed	LV (Primary)	Unearthed (Delta side)
		HV (Secondary)	Solidly earthed (Star side)
12.0	**Winding Insulation Test Voltages**		
12.1.	Lightning Impulse voltage withstand +ve/-ve (1.2/50µs Wave)		
i)	LV / HV	kV (Peak)	125 / 1300

Sl. No	Description	Unit	Client's Specification
12.2.	Switching Impulse voltage withstand +ve/-ve (250 / 2500µs Wave) for HV	kV(Peak)	-
12.3.	Power frequency voltage withstand		
	LV and HV (primary and secondary)	kV (rms)	50 / 570
13.0	**Temperature Rise**		
13.1.	Ambient temperature		Refer Section-B (Project Information)
13.2.	Maximum ambient air		
13.3.	Maximum daily average air		
13.4.	Maximum yearly average air		
13.5.	Cooling water (Maximum)		
13.6.	Temperature rise of top oil measured by thermometer	°C	55
13.7.	Average winding measured by resistance method	°C	60
13.8.	Winding hot spot temperature rise over yearly weighted average temperature of 32 °C	°C	61
14.0	Noise level		Maximum Noise Level 89 db (As Per NEMA TR-1)
15.0	**Tapping**		
15.1.	Tapping on windings		HV (star side)
15.2.	Whether on load / off-circuit		Off-Circuit tap changer (OCTC)
15.3.	Tapping range	%	+5% to -7.5%
15.4.	Tapping step	%	2.5
15.5.	Category of voltage variation (CFVV / VFVV / CbVV)		CFVV
15.6.	Capacity	Full / Reduced	FULL
16.0	**Tap Changer (OLTC/OCTC)**		OCTC
16.1.	Control		a) Automatic & Manual control from RTCC b) Manual control at Local
16.2.	Control cubicle	By Bidder / Purchaser	BY BIDDER
16.3.	Voltage class of OLTC	kV	**

Sl. No	Description	Unit	Client's Specification	
16.4.	Current rating of OLTC	A	**	
17.0	**Terminal Bushings**			
17.1	Particulars	LV Line End (Primary)	HV Line End (Secondary)	HV Neutral end (Secondary)
17.2	Rated Voltage class (Highest Voltage) – kV	24	420	36
17.3	Rated current class – A	BY BIDDER	BY BIDDER	BY BIDDER
17.4	Impulse (1.2/50µsec Wave withstand) – kV(Peak)	125	1300	170
17.5	One minute power frequency withstand (Dry & Wet) kV(rms)	50	570	70
17.6	Protected creepage distance – mm	31	31	31
18.0	**Bushing Current Transformer (BCT)**			
18.1	Application		BCT Core No.	BCT Particulars
18.2	HV line side for restricted earth fault protection (star side)		As per the requirement.	
18.3	For winding temperature measurement (star side)			
18.4	HV neutral side for restricted earth fault protection (star side)			
18.5	HV neutral side for standby E/F protection (star side)			
19.0	**Terminal Connections**			
19.1.	Terminal connections – A/B/C (See Notes)			
19.1.1.	LV Wdg (primary) Line end		Isolated Phase Bus Duct	
19.1.2.	HV Wdg (secondary) Line end		Gas Insulated Bus Duct	
19.1.3.	HV Wdg (secondary) Neutral end		Two (2) nos. 75x10mm Copper FLAT. Neutral point connected to FLAT supported on insulators on tank body from bushing to ground level.	
19.2.	Earthing Conductor			
19.2.1.	Material		GS / Copper (as per EB requirement)	
19.2.2.	Size		Two (2) nos. 75x12mm	
20.0	Nitrogen Injection Type Fire Protection System (NIFPS)		Not Required	
21.0	**Miscellaneous**			

Sl. No	Description	Unit	Client's Specification
21.1.	Impulse test		
21.1.1.	Full wave	Required / Not Required	Required
21.1.2.	Chopped wave	Required / Not Required	Required
21.2.	Type test	Required / Not Required	Required
21.3.	Special test	Required / Not required	Required
21.4.	Buchholz Relay		Double float type with potential free alarm and trip contacts
21.5.	Winding temperature indicator and Oil Temperature indicator for Local & Remote	Required / Not required	Required
21.6.	Oil level gauge		Prismatic
21.6.1.	Type	Magnetic / Prismatic	Both
21.6.2.	Dial size		150mm dia
21.7.	Transducer for Top oil temp.	Required / Not Required	Required
21.8.	Transducer for winding temperature and Windings	Required / Not Required	Required for windings
21.9.	Colour shade of final painting	Shade Number	631 of IS 5
21.10.	Bolted joint near base of tank	Required / Not Required	Required
21.11.	Skids	Required / Not Required	Required
21.12.	Wheel		
21.12.1.	Plain / Flanged		Flanged
21.12.2.	Unidirectional / Bi-directional		Bi-directional
21.12.3.	Additional wheels for stability required	Yes / No	Yes
21.13.	Vacuum withstand capability		
21.13.1.	Main tank with bushings, fittings and accessories		Full vacuum
21.13.2.	Radiators		Full vacuum
21.14.	Transformer to be transported:		
i)	Filled with oil		As per project requirement & site condition.

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Sl. No	Description	Unit	Client's Specification
ii)	Without oil with inert gas, gas cylinder, reducer connection, pressure gauge		As per project requirement & site condition.
21.15.	Additional drain valve to be located away from the transformer to operate if there is fire in transformer.		Required.
21.16.	Permissible PPM of insulating oil		PPM IN OIL - ppm < OR = 5 PPM
22.0	NOTES		
22.1.	The cooling system shall comprise of two 100% capacity heat exchangers and two 100% capacity oil pumps.		
22.2.	** - Data to be filled by the bidder.		
23.0	**Evaluation & Penalty**		
23.1.	Formula for evaluation of Bids		Evaluated price + (A x guaranteed no-load loss in kW) + (B x guaranteed load loss in KW) + (C x guaranteed cooler loss in kW)
23.2.	Rates of penalty for exceeding the guaranteed losses a) No load loss b) Load Loss c) Aux.loss	 Rs./KW Rs./KW Rs./KW	Refer Bid evaluation, Section -C2

8.53 Employer's Specification for ICT

Sl. No.	Description	Unit	Client's Specification
1.0	**General**		
1.1.	Application/Designation		**Interconnecting Transformer**
1.2.	Quantity		3 Nos.
1.3.	Installation	Indoor/ Outdoor	Outdoor type
1.4.	Type	2-Winding / 3-Winding	Auto Transformer
1.5.	Applicable Standard		IEC 60076 / IS 2026
1.6.	Three Phase / Single Phase Unit		1-Phase
1.7.	Rating of each Winding		
i)	HV Winding	MVA	67(This rating to be verified based on Load List)
ii)	LV Winding	MVA	67(This rating to be verified based on Load List)
1.8.	Type of Cooling		OFAF
1.9.	Cooler Bank Arrangement		5 X 25%
1.10.	Efficiency		>99%
2.0	**Ratings**		
2.1.	No load voltage		
i)	LV Winding	kV	132
ii)	HV Winding	kV	400
2.2.	Frequency	Hz	50
2.3.	Rating for each type of cooling		100% OFAF
2.4.	Percentage impedance at 75°C, at highest MVA base	%	2.5 * (with IS tolerance) at Principal tap
3.0	**Core**		
3.1.	Over fluxing		1.10 - CONTINUOUS 1.25 - 1 MINUTE 1.40 - 5 SEC 1.50 - 2 SEC
3.2.	Maximum Flux Density		At rated voltage 1.7 Wb/m2 At 110% rated voltage 1.9 Wb/m2
3.3.	Current Density		HV 2.5 A/sq. mm LV 2.5A/sq. mm.

Sl. No.	Description	Unit	Client's Specification
3.4.	Transformer External Short Circuit Withstand Capacity		Transformer shall be designed for bolted Short Circuit (SC) at its terminal (HV or LV) considering only self-percentage Impedance for 3 second thermal rating and dynamic rating as per IEC 60076.
4.0	**Winding Connections**		
4.1.	Winding Connection (Vector Group)		YNaOd11
4.2.	Direction of Power Flow		Bi-directional
5.0	**System Data**		
5.1.	5.2. System Voltage	5.3.	5.4.
i)	HV – Nominal / Highest	kV / kV	400 / 420
ii)	LV – Nominal / Highest	kV / kV	132 / 145
5.5.	5.6. Fault Level	5.7.	5.8.
i)	LV system	kA	50kA / 1 Sec (Refer SLD)
ii)	HV system	kA	63kA / 1 Sec (Refer SLD)
5.9.	System Neutral Earthing		
i)	(a) Effectively (b) Resonant (c) Non-effectively (d) Isolated	HV	Effectively (Solidly earthed)
		LV	Unearthed
6.0	**Winding Insulation**		
6.1	HV		Graded
6.2	IV		Graded
6.3	LV		Uniform
7.0	**Transformer Neutral**		
7.1	Type of earthing	7.1.	7.2.
i)	(a) Directly / Solidly earthed (b) Non-effectively (c) Isolated / Unearthed	LV	Solidly earthed (Star side)
		HV	Unearthed (Delta side)
8.0	**Winding Insulation Test Voltages**		
8.1.	Lightning Impulse voltage withstand +ve/-ve (1.2/50µs Wave)		
i)	LV / HV	kV (Peak)	650 / 1425

Sl. No.	Description	Unit	Client's Specification
8.2.	Switching Impulse voltage withstand +ve/-ve (250 / 2500µs Wave) for HV	kV(Peak)	-
8.3.	Power frequency voltage withstand		
i)	LV and HV (primary and secondary)	kV (rms)	275 / 630
9.0	**Temperature Rise**		
9.1.	Ambient temperature		Refer Section-B (Project Information)
9.2.	Maximum ambient air		
9.3.	Maximum daily average air		
9.4.	Maximum yearly average air		
9.5.	Cooling water (Maximum)		
9.6.	Temperature rise of top oil by thermometer	°C	55
9.7.	Maximum temperature rise of windings by resistance	°C	60
10.0	**Tapping**		
10.1.	Tapping on windings		HV
10.2.	Whether on load / off-circuit		Off - load
10.3.	Tapping range	%	+10% to -10%
10.4.	Tapping step	%	1.25
10.5.	Category of voltage variation (CFVV / VFVV / CbVV)		CFVV
10.6.	Capacity	Full / Reduced	FULL
11.0	Tap Changer (OLTC/OCTC)		OCTC
11.1.	Control		Manual control at Local
11.2.	Control cubicle	By Bidder / Purchaser	BY BIDDER
11.3.	Voltage class of OCTC	kV	**
11.4.	Current rating of OCTC	A	**
12.0	**Terminal Bushings**		

12.1	Particulars	HV	IV	LV	Neutral
12.2	Rated Voltage class – kV	420	145	52	36
	Rated current class – A	BY BIDDER	BY BIDDER	BY BIDDER	BY BIDDER

Sl. No.	Description		Unit	Client's Specification	
12.3	Impulse (1.2/50µsec Wave withstand) – kV(Peak)	1425	650	250	170
12.4	One minute power frequency withstand (Dry & Wet) kV(rms)	695	305	105	77
12.5	Protected creepage distance – mm	31mm/kV	31mm/kV	31mm/kV	31mm/kV
13.0	**Bushing Current Transformer (BCT)**				
13.1	Application		BCT Core No.		B C T Particulars
	HV line side for restricted earth fault protection (star side)		As per the requirement.		
	For winding temperature measurement (star side)				
	HV neutral side for restricted earth fault protection (star side)				
	HV neutral side for standby E/F protection (star side)				
14.0	Maximum Partial discharge level at Um				
14.1.	HV		pC	10	
14.2.	IV		pC	10	
14.3.	LV		pC	10	
15.0	Maximum Partial discharge level at 1.58 * Ur/ √3		pC	100	
16.0	Maximum Noise level at rated voltage, at principal tap & no load and all cooling active		dB	80	
17.0	Maximum Permissible Losses of Transformers			Same for constant ohmic and constant percentage type	
17.1.	Max. No Load Loss at rated voltage and frequency		kW	75	
17.2.	Max. Load Loss at rated current and at 75°C for HV and IV windings, at principal tap position		kW	440	
17.3.	Max. I2R Loss at rated current and at 75°C for HV and IV windings, at principal tap position		kW	330	
17.4.	Max. Auxiliary Loss at rated voltage and frequency		kW	10	
18.0	**Terminal Connections**				
18.1.	Terminal connections – A/B/C (See Notes)				
	LV Wdg (primary) Line end			XLPE Cable	
	HV Wdg (secondary) Line end			XLPE Cable	

Sl. No.	Description	Unit	Client's Specification
	HV Wdg (secondary) Neutral end		Two (2) nos. 65x10mm Copper FLAT. Neutral point connected to FLAT supported on insulators on tank body from bushing to ground level.
18.2.	Earthing Conductor		
	Material		GS / Copper (as per EB requirement)
	Size		Two (2) nos. 65x10mm
19.0	Nitrogen Injection Type Fire Protection System (NIFPS)		Required (With NIFPS Oil storage tank, complete metal piping with accessories)
20.0	**Miscellaneous**		
20.1.	Impulse test		
	Full wave	Required / Not Required	Not Required
	Chopped wave	Required / Not Required	Not Required
20.2.	Type test	Required / Not Required	Required for 1 Transformer
20.3.	Special test	Required / Not required	Required for 1 Transformer
20.4.	Buchholz Relay		Double float type with potential free alarm and trip contacts
20.5.	Winding temperature indicator and Oil Temperature indicator for Local & Remote	Required / Not required	Required
20.6.	Oil level gauge		Prismatic
	Type	Magnetic / Prismatic	Both
	Dial size		150mm dia
20.7.	Transducer for Top oil temp.	Required / Not Required	Required
20.8.	Transducer for winding temperature and Windings	Required / Not Required	Required for windings
20.9.	Colour shade of final painting	Shade Number	631 of IS 5
20.10.	Bolted joint near base of tank	Required / Not Required	Required
20.11.	Skids	Required / Not Required	Required
20.12.	Wheel		
	Plain / Flanged		Flanged

Sl. No.	Description	Unit	Client's Specification
	Unidirectional / Bi-directional		Bi-directional
	Additional wheels for stability required	Yes / No	Yes
20.13.	Vacuum withstand capability		
	Main tank with bushings, fittings and accessories		Full vacuum
	Radiators		Full vacuum
20.14.	Transformer to be transported:		
	Filled with oil		As per project requirement & site condition.
	Without oil with inert gas, gas cylinder, reducer connection, pressure gauge		As per project requirement & site condition.
20.15.	Additional drain valve to be located away from the transformer to operate if there is fire in transformer.		Required.
20.16.	Permissible PPM of insulating oil		PPM IN OIL - ppm < OR = 5 PPM
21.0	NOTES		
21.1.	2x50 % Capacity separately mounted radiator bank shall be provided.		
21.2.	** - Data to be filled by the bidder.		
22.0	**Evaluation & Penalty**		
22.1.	Formula for evaluation of Bids		Evaluated price + (A x guaranteed no-load loss in kW) + (B x guaranteed load loss in KW) + (C x guaranteed cooler loss in kW)
22.2.	Rates of penalty for exceeding the guaranteed losses a) No load loss b) Load Loss c) Aux.loss	 Rs./KW Rs./KW Rs./KW	Refer Bid evaluation, Section -C2

8.54 Employer's Specification for SR

SL. No.	Description	Unit	Technical Particulars
1.0	**General**		**Shunt Reactor**
1.1	Application (Line/Neutral) / Designation		Shunt Reactor At GIS Bus
1.2	Quantity		80 MVAR, 400kV-1 set
1.3	Installation		OUTDOOR TYPE
2.0	**System Details**		**Refer SLD**
2.1	Nominal System Voltage	kV	400
2.2	Highest System Voltage	kV	420
2.3	Short Circuit Level (SYMM)	kA	63
3.0	**Ratings**		
3.1	Rated Voltage	kV	400
3.2	Number of Phases and Rated Frequency	Ph & Hz	3 ph & 50 Hz
3.3	Rating (Three Phase/Single Phase)	MVAR	80 MVAr for 400 kV system However, it shall be as per detail design and engineering.
3.4	Winding Connection		
3.5	Impedance per Phase	Ohms	
3.6	Tolerance on Impedance	%	
3.7	Cooling		OFWF
3.8	Neutral Earthing		
3.9	Duration of Short Circuit Current	Sec.	
3.10	Linearity of Voltage Curve		
3.11	Max. Crest Value of Third Harmonic Content in Phase Current		3% Of the crest value of fundamental.
3.12	Permissible Current Unbalance among different phases at Max. System Voltage	%	
3.13	Ratio of Zero Sequence Reactance to Positive Sequence Reactance		

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SL. No.	Description	Unit	Technical Particulars
3.14	Noise Level at Rated Voltage and Frequency	dBA	
3.15	Whether Full or Graded Insulation		
4.0	**Insulation Withstand**		
4.1	Impulse (1.2/50µ sec Wave)	kVp	
4.2	Switching Surge (250/2500µ sec. Wave)	kVp	
4.3	Power Frequency Test Voltage to Earth for Star Point of Winding		
i)	Directly Earthed Neutral	kVrms	
ii)	Neutral Earthed Through Neutral Reactor	kVrms	
5.0	TEMP. RISE		
5.1	Reference Ambient	°C	50
5.2	Oil by Thermometer	°C	40
5.3	Winding by Resistance	°C	45
5.4	Connector/clamp	°C	45° C above ambient
6.0	**BUSHINGS**		
6.1	Line Terminal Bushing Type		
6.2	Neutral Terminal Bushing Type		
i)	Directly Earthed		
ii)	Earthed Through Neutral Reactor		
6.3	Impulse (1.2/50µsec.) Wave Withstand		
i)	Line End	kV	
ii)	Neutral End	kV	
6.4	Minimum Clearance in Air	mm	
i)	HV Phase to Phase		
ii)	HV Phase to Earth		

SL. No.	Description	Unit	Technical Particulars
6.5	Minimum Creepage Distance	mm	
i)	HV Line End Bushing		
ii)	Neutral End Bushing		
6.6	Bushing CT Requirements (VA & Accuracy)		
i)	Line Side		
a)	CORE-1		
b)	CORE-2		
c)	CORE-3		
d)	CORE-4		
ii)	Neutral Side		
a)	CORE-1		
b)	CORE-2		
c)	CORE-3		
d)	CORE-4		
7.0	TERMINAL CONNECTOR		
7.1	Line End Bushing		
7.2	Neutral End Bushing		
8.0	EARTHING TERMINAL		
8.1	Two Earthing Terminals Suitable For Purchaser's Conductor		
i)	Material		
ii)	Size		
9.0	MISCELLANEOUS		
9.1	Wheels		
i)	Plain/Flanged		

SL. No.	Description	Unit	Technical Particulars
ii)	Unidirectional / Bidirectional		
9.2	Skids Required		YES
9.3	Buchholz Relay Required		YES
9.4	Winding Temperature Indicator Required		YES
9.5	Dial Size of Magnetic Oil Level Gauge		

8.55 Applicable Standards

Sl. No.	Description	Standards	
1.	Power Transformer	IS:2026 CBIP:317	IEC: 60076
2.	Fittings and Accessories for Power Transformer	IS: 363	
3.	Insulating Oils for Transformer and Switchgear	IS: 335	IEC: 60296
4.	Bushing for alternating voltage above 1000 V	IS: 2099	IEC: 60137
5.	Current transformers	IS: 2705	IEC: 60185
6.	Gas operated relays	IS: 3637	
7.	Industrial cooling fans	IS: 6272	
8.	Guide for Loading of oil immersed transformers	IS: 6600	IEC: 60076-7
9.	Specification for dimensions of porcelain bushing	IS: 3347	
10.	High voltage test technique	IS:	IEC: 60
11.	NEMA standard publication for Power transformers	NEMA-TR-1	
12.	Porcelain post insulators for systems with nominal voltage greater than 1000 V	IS: 2544	IEC
13.	Climate proofing	IS: 3202	IEC
14.	Loading of immersed transformer	IS: 6600	IEC: 354
15.	Degree of protection	IS/IEC 60529	IEC:60529
16.	Tests	IS: 2026	IEC:60076
17.	Tolerances on guaranteed particulars	IS: 2026	IEC:60076
18.	Electrical insulation classified by thermal stability	IS: 3637	IEC
19.	Climate proofing	IS: 3202	IEC
20.	Code of practice for phosphating of iron and steel	IS:6005	



8.56 Mandatory Spares

Sl. No.	Transformers	Unit	Qty
1	HV Bushing	Nos. of each type & rating	3
2	LV Bushing	Nos. of each type & rating	3
3	Neutral bushing	Nos. of each type & rating	3
4	Oil cooler pumps with motor (complete assembly)	Nos. of each type & rating	2
5	Bearing for Oil circulation pump	Nos. of each type & rating	3
6	Buchholz relay complete (main tank)	Nos. of each type & rating	2
7	Local Winding temperature indicator	Nos. of each type & rating	2
8	Remote winding temperature indicator with sensing device and matching unit	Nos. of each type & rating	2
9	Oil temperature indicator	Nos. of each type & rating	2
10	Pressure relief device	Nos. of each type & rating	2
11	Magnetic oil level gauge	Nos. of each type & rating	2
12	Set of Valves	Nos. of each size and type	2
13	Set of starters, contactors, relays and switches for electrical control panel	Nos. of each type & rating	2
14	Remote tap position indicator	No. of each type & rating	1
15	Oil flow indicator	sets of each type & rating	2
16	Terminal connector	sets of each type & rating	2
17	Aircel	Nos. of each type & rating	2
18	Gaskets for Bushings, flanges, manholes	sets of each type & rating	2
19	Insulating oil	10% of quantity of oil (20	

CHAPTER 9: 420 kV GAS INSULATED SWITCHGEAR

9.1 Scope of Work

This Specification covers the requirements of sizing, design, engineering, material selection, constructional features, manufacture, inspection and testing at the VENDOR'S or his SUB-VENDOR'S Works, delivery to Site including transit insurance, installation, testing & commissioning, performance testing, training of employer's personals and handling over of Gas Insulated Switchgear (GIS) rated as mentioned below for indoor use on 50 Hz Power systems.

420kV Gas insulated switchyard (GIS) with double bus bar type consisting of four generator/transformer incoming circuit breaker bay modules, two outgoing overhead line circuit breaker bay modules, one shunt reactor circuit breaker module, one ICT bay module, one bus coupler circuit breaker bay module, Bus PT, XLPE cable terminal connection and control cabinets for each bay. The GIS will be connected to the main power transformers and 400kv XLPE cables will connect GIS to Pothead yard.

9.2 Codes and Standards

i) The design, material, construction, manufacture, inspection, testing and performance of the gas insulated switchgear (GIS) and accessories shall comply with all currently applicable statutes, regulations, and safety codes in the locality where the equipment will be installed. Nothing in this specification shall be construed to relieve the VENDOR of this responsibility.

ii) The codes and standards mentioned in the various specifications and requirements specified in the enquiry document shall be latest as on the day of award of contract of the works unless otherwise specified. Contractor shall be responsible to inform to the Consultant/ Owner in case of any revisions/re-affirm/amendment in the relevant codes and standards after the date of award of contract within 30 days of the issue of such revision/re-affirm/amendment of the code/ standard. Consultant/ Owner may approve use of the earlier code/ standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed.

iii) The applicable Codes and standards are specified in Data Sheet A2. However, for some special applications the GIS may have to conform to some higher requirements, which will be specified in Data Sheet A1. In such specific cases, this specification shall take precedence over the standard requirements indicated in the applicable Industry Standards.

9.3 Components of GIS Assembly

The components of switchgear assembly having compact and modular design shall essentially consist of following items and their accessories specified in subsequent clauses:

i) Circuit breakers

ii) Disconnecting Switches

iii) Ground switches (Maintenance and High-Speed types)

iv) Voltage transformers (with disconnecting link/externally operated isolation switch)

v) Current transformers (If CT is installed in breaker gas compartment, insulation class for CT shall be class F)

vi) SF6 Surge Arrestor (where applicable)

vii) Partial Discharge Monitoring devices (where applicable)

viii) Terminations - overhead line (SF6 to air bushing), power cable (SF6 to cable sealing end with isolating link/provision for test probe connection) and transformer (SF6 to Oil bushing) terminations.

ix) Bus bars, Bus enclosures and accessories with different bus arrangements.

x) Local control panels and operating mechanism cabinets.

xi) SF6 GIS Busduct Indoor/outdoor (where applicable)

xii) Other item specifically covered in elsewhere in the Tender document.

xiii) Pressure/density monitors and switches

xiv) GIS supporting structures and buffer modules (as applicable)

9.4 Design and Constructional features

9.4.1 General

i) The switchgear assembly shall be suitable for indoor or outdoor installation as specified in enclosed Data Sheet A1. Constructional features shall be selected not only to withstand satisfactorily the specified atmosppheric conditions but allow for thermal expansion during its normal use, without any damage.

ii) Each bay shall be arranged in compact and modular design with individual equipment modules connected to form a complete assembly for the intended GIS Bus configuration.

iii) The equipment and connections within each compartment shall be arranged so as to allow removal and replacement of any section both during normal working conditions with minimum disturbance to adjacent bays in-service pressurised sections.

iv) The GIS Equipment shall be complete with all necessary supports, ladders, galleries, staircases, catwalks, movable platforms, or walkways (for accessing the equipment above two meters for maintenance and operation), mechanism cabinets, internal cable raceways etc for each bay and it shall be of modular construction and extendable design. All structures, galleries, staircases, and walkways shall conform to the relevant Occupational Safety and Health Administration (OSHA)standards.

v) Minimum assembly work shall be envisaged during installation. The GIS shall be supplied as completely factory assembled switchgear bays, within shipping/transportation limits.

vi) The GIS shall be installed on suitable mounting pads or supporting frames/structures with provision for levelling, including fasteners to foundation, which shall also be included in the supply. Support-structures shall be designed and fabricated to withstand the short circuit forces of the ground fault current as well as prevent excessive vibration during switching operation or faults.

vii) The GIS shall be provided with expansion joints and flexible connections across flanges, where several enclosures are connected in the longitudinal direction, such as main bus. Expansion joints provided for installation alignment shall be locked in place when alignment is complete. Expansion joints for compensation of thermal expansion and erection tolerances shall have the means to preserve mechanical integrity of the enclosure and the plug-in contacts for the conductor. Provision shall be made for expansion of GIS on either side of GIS.

viii) All modules of the GIS switchgear and components of the same rating and construction, which may need to be replaced, shall be completely interchangeable.

ix) The GIS interface points shall be carefully coordinated with other equipment such as overhead lines, cables, transformers, reactors, capacitor banks, etc. supplied by other manufacturers in order to ensure full compatibility. The GIS manufacturer shall also specify the dimension and mounting details, weight, etc. of the spring/bellow used between GIS bus duct termination with transformer. The design criteria for outdoor portion of the GIS bus duct leading to SF6-to-Air Overhead Line Termination shall be as mentioned in clause 6.2 and in the Data Sheet A1. The surge impedance of GIS to

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cable or overhead line termination shall be reduced by suitable construction/arrangement of GIS module. The surge impedance values for all GIS modules shall be furnished by the Vendor.

x) The switchgear and all its components and accessories shall be designed for minimum maintenance during service. The manufacturer shall state the minimum interval between minor inspections (which will be restricted to visual checking and adjustments of external parts only) and major inspection/overhaul, including refilling or replenishment of gas and cleaning of the contaminant or filter in the circuit breaker chamber(s). Suitable glass window/telescopic port shall be provided in the circuit breaker, disconnect and grounding switch modules for ensuring proper contact making. The bearings and other such parts shall be permanently lubricated for the entire service life

xi) To facilitate transport and handling, lifting eyes or other suitable attachments shall be provided with each GIS module.

xii) Each module of switchgear, consisting of individual elements intended to be directly connected together, shall be constructed as a transportable assembly suitable for shipping and transportation without being dismantled. Dry Nitrogen gas filling shall be used during transportation instead of SF6.

xiii) All new gaskets, sealants, and desiccants for permanent sealing of all field joints and all access covers, removed during assembly, shall also be provided.

xiv) The Bus and all current carrying parts shall be made of electrical grade Aluminium alloy. In certain specific requirements electrolytic copper may be provided if specified in Data Sheet A1. All interconnecting sections of current transferring parts shall be silver-plated. Joints and couplings between dissimilar metals shall be avoided to prevent galvanic corrosion.

xv) All supporting steel work shall be hot dip galvanized. All welding in GIS shall conform to the applicable standards mentioned in Data Sheet A2.

xvi) A partition separating a compartment filled with insulating gas from a neighboring compartment such as a cable box, filled with liquid, shall not show any leakage affecting the dielectric properties of the two media.

xvii) All piping for SF6 gas and hydraulic operating mechanism including their fittings shall be made of copper, brass, or stainless steel.

xviii) All external connectors and terminal pads shall be made of aluminium or copper with tinplating.

xix) The design of the equipment shall be such that the agreed permitted movement of foundations and mechanical or thermal effects do not impair the assigned performance of the equipment.

xx) The CT and PT secondary windings including the cable glands shall be able to withstand electromagnetic and electrostatic disturbances as per IEC without damage or malfunction. This applies both under normal operation and under switching conditions, including interruptions of fault current in the main circuit.

xxi) GIS modules shall have gas tight barrier insulator partitions such that fault in one compartment will not affect the normal operation of the adjacent compartment The section shall be designed:

xxii) To minimize operation shutdown when the gas pressure is reduced due to leakage or for maintenance purpose.

xxiii) To minimize the quantity of gas that must be evacuated and recharged before and after maintaining any item of equipment.

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xxiv) Each section shall be provided with necessary valves to allow evacuation and refill of gas without evacuation of any other section.

xxv) Gas barriers shall have PD sensors.

xxvi) In event of arcing in compartment the arc should not extend to neighbouring compartment. Any failure to the enclosure of compartment shall not lead to damages in neighbouring compartment. In view of this continuous busbar without gas segregation is not acceptable.

9.5 Ratings

i) The specific ratings of the GIS equipment shall be as specified in the Data Sheet A1 and Single line diagram.

ii) The switchgear shall be capable of carrying the specified rated current continuously at the specified ambient conditions in Data Sheet A1, without temperature rise of various parts exceeding the limits stated in the applicable standards mentioned in Data Sheet A2. The maximum temperature of the external surfaces shall be 70°C as per the applicable standards mentioned in Data Sheet A2.

iii) The switchgear and its associated apparatus shall produce minimum noise during service. The maximum noise level shall be indicated by the manufacturer and be subject to approval by the Purchaser.

iv) All equipment and components of the switchgear including bus support insulators shall be free of partial discharges when operated at the rated voltage. The maximum permissible partial discharge level shall not exceed 5 pC of the test voltage specified in the applicable standards mentioned in Data Sheet A2. Any sub assembly containing components with permitted partial discharge intensity greater than 5 pC shall be considered acceptable if the discharge level does not exceed 10 pC.

v) The insulation level requirements shall be as specified in the applicable standards mentioned in Data Sheet A2.

9.6 GIS Enclosure

i) The GIS shall be of either single-phase enclosure type or three-phase enclosure type for voltage levels of 220kV and below and of single-phase enclosure type for voltage levels of 400kV and above as specified in Data Sheet A1.

ii) The enclosure shall be capable of sustaining without damage all mechanical, electrical, and thermal shocks that may occur in service during normal and fault conditions, including pressure effects of internal fault arc current of specified short circuit level and time. The enclosure assembly, material and design shall be such as to minimize induced electrical losses and heating effects which could occur in service under normal and fault conditions.

iii) A single gas zone for single-phase GIS enclosures within the same gas compartment, excluding the circuit breaker (CB), may be established through external piping, with appropriate valves provided to ensure proper isolation.

iv) The GIS enclosure shall be safe to touch and fully ensure operational security and personnel safety under all normal and fault conditions with the maximum allowed induced voltage in the enclosure of 65 volts.

v) The enclosure shall be designed to withstand internal fault at the rated short circuit current level and consequent pressure for a period specified in Data Sheet A1 without a burn through.

vi) The GIS enclosures shall have a minimum burn-through time greater than the back-up clearance time as specified in the Data Sheet A1, if rupture disc/pressure relief device is not provided. The burn-through time shall be in accordance with the applicable standards mentioned in Data Sheet A2. GIS manufacturer has to furnish pressure rise

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curve in support of minimum burn-through time along with test report for internal arc withstand.

vii) Gas enclosures and flange joints shall be designed to withstand 1.5 times the operating pressures by provision of suitable reinforcement(s) at all the required locations.

viii) The construction and thickness of the GIS enclosure shall conform to the applicable standards mentioned in Data Sheet A2.

ix) For enclosures and parts thereof, the strength of which has not been fully determined by calculation, proof tests as per the applicable standards mentioned in Data Sheet A2 shall be performed to demonstrate that they fulfil the requirements.

x) Interior finishing material of the enclosure shall not contain any substances which could contaminate the enclosed SF6 gas or affect its insulating properties. The GIS enclosures shall be provided with suitable devices like particle traps/absorbers at suitable location to eliminate conducting particles, as required.

xi) The exterior surface finish of the enclosure shall be finalized in agreement with the Purchaser. The actual colour shade shall be based on the end user's requirement. The protective finish shall prevent deterioration due to corrosion, humidity, temperature, ageing due to weather, attack from fungus or rodents for minimum of five years.

xii) SF6 Gas monitoring and service piping including all fittings and accessories shall be of copper, brass, or stainless steel.

xiii) All steel structures above grade level required for supporting the switchgear, including SF6/Air Bushing supports and feeder bus duct supports, etc., shall be hot dip galvanized and shall be supplied as a part of switchgear package.

xiv) The GIS enclosure shall have an enclosure protection to suit the gas leakage restrictions as per IEC standards. All components of the GIS shall be able to withstand the environmental conditions for outdoor application including temperature variation during the various seasons.

xv) The degree of protection for all terminal boxes, operating mechanism enclosure, control cabinets, auxiliary equipment enclosures and all accessories shall be IP 43 for Indoor application and shall be IP 55 for Outdoor application.

9.7 GIS Gas sections

i) The GIS shall be divided into compartments separated by individual gas barriers. The gas barriers shall be suitably identified on the outside of the GIS.

ii) Long bus runs shall be sectionalized into a number of gas compartments such that failure in any gas section does not affect the adjacent gas sections.

iii) The GIS module design shall be such as to minimize the quantity of gas that has to be evacuated and then recharged before and after carrying out maintenance. Cable box where cable-sealing end is installed shall have its own independent gas compartment, with gas monitoring.

iv) Gas compartments shall be designed in such a way that voltage transformers can be easily removed without degassing any of the busbar compartments.

v) Compartmentalisation shall be provided for circuit breaker, Busbar, Current transformer, Voltage transformer, Surge arrester (if specified in data sheet), Disconnector along with Earthing switch and Cable sealing end, SF6 to Air Bushing, SF6 Bus Ducts in the switchgear assembly.

vi) The material shall be chosen, and the parts designed such that they retard the propagation of any flame resulting from accidental overheating in the switchgear and control gear.

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9.8 SF6 Gas system and associated devices

i) For GIS new SF6 shall conform to the applicable standards mentioned in Data Sheet A2 and used SF6 shall conform to the applicable standards mentioned in Data Sheet A2 after removing moisture and other impurities.

ii) The SF6 gas manufacturer shall provide the data regarding gas characteristics corresponding to the degree of deterioration beyond which treatment or replacement of gas would become necessary along with procedural instructions for gas treatment to restore original quality.

iii) The sealing system shall also effectively ensure against the ingress of moisture, dust and other contaminants into gas compartments. SF6 gas relative leakage rate of each gas compartment shall not exceed 0.5% per year over the life time of the switchgear (as per applicable standard). Double "O" ring design be adopted to ensure Gas tightness. The material and method of sealing used shall be stated in the tender.

iv) Leakage rate shall be guaranteed for a total duration of warranty period and latent defect period after warranty period. Warranty period and latent defect period shall be as per contractual Terms and Conditions. In case the leakage under the specified conditions is found to be greater than 0.5%, the manufacturer shall rectify same and shall supply the total gas requirement/consumables/service at free of cost till satisfactory rectification of the problem.

v) Each equipment in the GIS enclosure shall be sectionalized into modular units or compartments, each compartment separated by gas barriers with an effective sealing system. Each compartment shall be provided with the necessary piping and valves to allow isolation, evacuation and refilling of SF6 gas without evacuating of any other section.

vi) Gas barriers and sealing systems shall have adequate mechanical strength to withstand the dynamic forces caused by short circuits, and effects of internal arc faults as well as maximum pressure differential that could exist between adjoining compartments, i.e. with full vacuum drawn on one side of the barrier and 1.5 times the rated operating pressure on the other side.

vii) SF6 gas in each individual compartment shall be monitored by suitable gas density or temperature-compensated gas pressure gauges and two stage temperature compensated pressure (gas-density continuous monitoring) switches/ relays to monitor the loss of SF6 gas. The dial of the pressure gauges shall be graduated to read pressures and coloured green, yellow and red to indicate normal, Alarm Stage I and Alarm Stage II pressure conditions. Gas-density monitor shall be readable from the ground. Potential-free auxiliary contacts for two-stage alarm initiation shall be provided. These alarm contacts shall be wired to the annunciator in the respective GIS bay control panel.

viii) Separate gas density monitor switch shall be provided for each equipment compartment including but not limited to Circuit Breaker, Current Transformer, Voltage Transformer, Surge Arrester, Isolator (separate monitor for bus bar and bus Isolator) & Earth Switch etc (for each compartment).

ix) The dial of the pressure gauges shall be graduated to read pressures to indicate normal and different alarm pressure conditions. Gas-density monitor shall be readable from the ground. Potential-free auxiliary contacts for alarm initiation shall be provided. These alarm contacts shall be wired to the annunciator in the respective GIS bay control panel.

x) For circuit breaker: The gas-density monitors shall be capable of being calibrated with the monitored equipment in service. If the gas-density monitor has a visual indicator, it shall be readable from the ground. Each relay shall be provided with two convertible (NO and NC) potential-free auxiliary contacts for alarm initiation. These alarm

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contacts shall be wired to the annunciator in the respective GIS bay control panel along with provision for remote monitoring. Separate gas density monitors shall be provided for each phase of the circuit breaker.

xi) Following alarm levels shall be provided:

a) **SF6 gas pressure low (1st stage alarm-for all compartments)**

This will be used to annunciate the SF6 gas pressure low alarm. Two sets of potential free contacts for remote indication/ annunciation shall be provided.

b) **-SF6 gas pressure very low (2nd Stage alarm/trip-for all compartment)**

This is the minimum gas density at which the manufacturer will guarantee the insulation rating of assembly. At this level the device contact shall trip the breaker. Two sets of potential free contacts for remote indication/ annunciation shall be provided.

c) "Breaker Closing Block" Level (for CB compartments only)

The 1st Stage low gas pressure alarm of the circuit breaker (any phase) shall block the closing operation of the circuit breaker. This signal shall also be configured for remote indication and annunciation. All gas compartments shall have their own coupling valve, so that all maintenance jobs, like drawing gas samples or conditioning and replenishing the SF6 gas can be carried out during normal operation of the switchgear without difficulty or loss of gas.

xii) In the event of gas leakage, all parts of the switchgear in the affected compartment shall be able to withstand continuously the maximum rated voltage with SF6 gas at atmospheric pressure.

xiii) It shall be possible to test and replace each pressure gauge and the density switch/relay with the GIS in service.

xiv) The gasket shall be synthetic elastomeric type. The gasket shall resist oil and waste by-products of the SF6 gas decomposition. The gasket shall have minimum surface imperfection and deformation in service life of GIS and also low gas and moisture permeability.

xv) Gas leakage detectors of an approved type shall be provided.

xvi) It shall be possible to test all gas monitoring relays/devices without de-energizing the primary equipment & without reducing pressure in the main section. Plugs & sockets shall be used for test purposes. It shall also damp the pressure pulsation while filling the gas in service, so that flickering of the pressure switch contacts does not take place.

xvii) If specified in Datasheet/ bill of materials, GIS shall be equipped with the remote online GAS monitoring system. The gas pressure of each compartment shall be able to be monitored remotely from SCADA. The system shall have the facility to pinpoint the exact gas module in the bay where gas leakage problem is there.

xviii) At each gas compartment, provisions shall be made for connecting online moisture measurement instrumentation and the gas service cart. The moisture content in the gas shall not exceed 150 ppmv (parts per million per volume) in circuit breakers, and 250 ppmv at rated pressure at 20degC in other equipment. Provision for disconnection of gas pipelines shall be incorporated. 100µm or smaller sintered stainless steel particle filter disk, suitable for pressure involved, shall be installed at the gas service connection.

xix) Filters shall be inserted in all the gas compartments in addition to circuit breaker compartment. Filters for gaseous arc by-products shall be installed before the bursting disc/pressure relief device, so that arcing by-products will be removed in a controlled and filtered way. SF6 gas filters shall be as follows:

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a) For moisture (H2O): Desiccant material such as Al2O3, also called drying agent. The recommended particle size is 2-5 mm.

b) For gaseous arc by-products: Molecular sieve with a pore size of 4Å. Materials used for this purpose should not be regenerated.

c) For particles (generally dust residues) or solid arc by-products: filter to remove particles with a size larger than 1 µm.

xx) A coloured diagram showing various gas compartments, pipings, interconnections, valves, orifices and isolations to prevent current circulation, necessary controls and monitoring systems etc. together with normal and alarm ranges shall be provided in the drawing holder on the inside of each control cubicle for ease of supervision.

xxi) The location of gas barrier insulators shall be clearly and permanently marked on the finished external surface of the GIS enclosures.

xxii) The switchgear assembly supply shall include the initial complete filling of SF6 gas for the assembly, and in addition, any gas lost during installation and commissioning procedures.

xxiii) The switchgear assembly supply shall include an additional 10% supply of gas complete with containers and monitoring equipment for use during the warranty period.

xxiv) The total design shall incorporate facilities for SF6 storage adjacent to the installed switchgear assembly.

xxv) The Vendor shall recommend procedure for SF6 handling.

9.9 Gas Seals

i) All gas seals shall be designed to ensure that leakage rates are kept to specified minimum under all normal pressure, temperature, electrical load and fault conditions. Double gas seals with provision to monitor the failure of first seal shall be provided.

ii) The material for the seals shall be non-deteriorating.

9.10 Support insulators

i) The support insulators and Gas section barriers/ insulators will be of solid moulded composite, epoxy resin and shall be manufactured from the highest quality material.

ii) All insulators shall be free of partial discharge at a voltage, which is at least 10% greater than the maximum service voltage. A test certificate in this regard, as a proof, shall be furnished.

iii) The solid insulators shall be non-hygroscopic, track resistant and free from voids and contaminants. The design shall be such as to reduce the electrical stresses in the insulators to a minimum.

9.11 Pressure relief device / rupture discs

i) Pressure relief devices or Rupture Discs shall be provided in each gas section where it is considered necessary to protect the main gas enclosure from damage or distortion during the occurrence of abnormal pressure increase or shock waves generated by internal electrical fault arcs.

ii) The effect of an arc shall be confined to the compartment in which it has been initiated and under no circumstances shall be allowed to spread out to adjacent compartments/Gas Sections/Terminations or other parts of the GIS.

iii) Pressure relief devices shall be used for all gas compartment. Automatic external pressure relief devices shall be provided as a precaution against bursting of enclosure. Internal pressure relief devices shall not be acceptable. The bursting pressure of relief devices shall be effectively co-ordinated with the rated gas pressure and the pressure

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rise due to arcing to avoid any mal operation in normal operating conditions. All gas compartments are to be equipped with rupture diaphragms and if necessary, with gas diverter nozzles are arranged in a way that, if the rupture diaphragm burst, the gas flow is guided away in a direction not unnecessary hazardous to either personnel or equipment.

iv) The pressure relief device or rupture discs shall be located away from gauges, meters, gas filling ports and gas density device calibrating point.

v) Deflectors shall be provided to direct all escaping gases, arcing products and fragments of the bursting rupture discs away from operating personnel and nearby devices. The direction of the escaping gas shall so oriented so as to cause no damage to the GIS equipment.

9.12 Expansion or flexible connections for enclosure

i) The number and position of expansion joints and flexible metallic connections are to be determined by the GIS Manufacturer to ensure that the complete installation will not be subjected to any expansion stresses or TEV which could lead to distortion or premature failure of any component of the GIS equipment, support structures or foundations.

ii) The arrangement of assembly offered shall provide adequate access for operation, testing and maintenance of each bay and shall be subjected to approval of Purchaser.

9.13 SF6 Gas Monitoring devices

i) All gas compartments must have their own independent and reliable gas supervision alarm system with annunciations as per Clause 7.2.10.

ii) The devices shall be gas density or temperature compensated gas pressure gauges electrically isolated and independently adjustable, dust proof and vibration resistant. Gas monitoring devices shall be capable of being checked with the high-voltage equipment in service.

iii) Two potential free electrical contacts shall be provided exclusively for each of the above alarm/ trip conditions for wiring to supervisory control system. These contacts shall be in addition to those required for local indication and trip and shall be wired to the cable termination blocks in the local control panels.

9.14 Layout of GIS

i) The layout shall be such that future alterations and extensions can be undertaken in either direction without requiring major shutdown or Bus outage or adjacent bay outage. Manufacturers shall include in their bid detailed plans to describe the process of expansion.

ii) The layout shall also ensure maintenance or removal of a circuit breaker or disconnect switch from a particular bay will not involve removal from service of adjacent bay disconnect switch or main bus sections.

iii) The layout shall ensure that GIS bus link section is provided for future extension of the GIS buses to avoid de-gassing and modification of the existing bus and the Buffer modules.

iv) The physical layout shall ensure free movement of the SF6 Gas Cart and easy access to all components of the GIS for maintenance purposes.

v) The inter-bay width shall be sufficient to allow access to all drive mechanisms and other termination boxes without the need of dismantling the apparatuses.

vi) Sufficient clearances around bushing for cable HV AC testing shall be provided.

vii) Provision of cable testing during fault location and identification without removal of cable/VT, VT isolator to be provided.

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viii) Vendor shall provide the GIS/XLPE cable, GIS/AIR bushing and GIS/Oil bushing connection interface drawings and details.

ix) The GIS shall be extendable on both sides and all the components required for enabling future extension like end conductor, gas barrier, end plates, etc shall be considered if specified in Data Sheet A1. Bidder has to furnish the required drawings for expansion interface of future bays along with the bid.

x) No changes are made to the enclosure during future extension. During erection/testing of extension, outage of only one bus bar and associated equipment will be available. Under no circumstances outage of both the buses (complete station shutdown) will be permissible. Bidder to ensure that the adjacent bay will remain in service during extension as well as maintenance and testing of one bay. The bidder will give the step-by-step procedure for the extension of bays on either side of GIS.

9.15 Partial discharge (PD) monitoring system

The On-Line Partial Discharge Monitoring (PDM) System if requested as per Data sheet A1 shall be complete, consisting of the following major devices.

i) Devices:

ii) Sensors/Couplers

iii) Local Data Acquisition, Monitoring and Analysis System.

iv) Remote Data Acquisition, Monitoring and Analysis System (SCADA)

v) User Interface Data Display system

vi) LAN Cabling and associated devices

vii) Data storage/retrieving system

The PD sensors and all devices of the PD monitoring system shall meet the following minimum requirements. However, any additional requirement necessary for the satisfactory and safe performance of the system shall be deemed to be included in the scope of supply.

i) The PDM system shall conform to the requirements of the applicable IEC specifications.

ii) The PDM system shall operate on a safe DC operating voltage derived from the D.C system available in the station. Suitable DC to DC converters shall be utilized for the purpose with a complete redundancy for a fail proof system.

iii) The PDM system sensors or couplers shall be designed not to spark over when open circuited.

iv) The PDM system sensors/couplers shall be free from the Cellular/Radio signal interference and shall not record wrong signals.

v) The PDM system shall have a self-diagnostic feature to detect failure of the system components. No single component failure shall affect the satisfactory performance of the system.

vi) The PDM sensors/couplers when installed internal to the GIS shall not cause leakage of SF6 gas.

vii) The PDM system shall be provided with a monitoring system locally within the Substation and shall also have provision for remote connection to SCADA system through Fiber Optic Communication links. All required devices for a total monitoring locally and remotely shall be provided.

viii) The Data capture resolution time shall be 1 ms or less.

ix) The Data Storage system shall be capable of storing data up to 30 days.

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x) The monitoring system shall be compatible with IEC 60870-5-104 protocol or IEC 61850 (as applicable) and shall be able to communicate via the Internet (TCP/IP protocol), Ethernet/ICCP link.

xi) The PDM system shall be designed in such a way that the failure of the power supply will not result in any data loss captured up to the point of Power Supply failure.

Note - The Offline Partial Discharge Monitoring (PDM) System by portable device, if requested as per Data Sheet/ Bill of Materials shall be complete in all respect for successful operation. In this case, adequate sensors for PD monitoring shall be provided. Philosophy for locating the sensors shall be provided for approval from Owner/ Consultant.

9.16 Busbar Assemblies

i) The busbar system shall be designed to withstand thermal expansions and carry rated normal current and withstand short circuit currents as specified in data sheets.

ii) Conductors/Busbars material shall be as specified in Data Sheet A1. The electrical connections between the various gas sections shall be made by means of multiple contact connectors (plug-in type) so that electrical connection is automatically achieved when fixing one section to another. Field welding of the conductor is not acceptable.

iii) The busbar system shall be sectionalized for each bay and contained in individual SF6 gas tight bus compartments to prevent contamination of the gas of the whole bus bar due to fault in one bay zone and refill lesser quantity of SF6 gas. Straight through bus bar shall not be accepted.

9.17 Name Plate

i) GIS and all its operating devices and main components shall be provided with nameplates, as agreed between Vendor and User. The nameplates shall be durable and clearly legible. The individual nameplates of the components can be simplified, provided common information for the GIS is stated on one nameplate. The Vendor shall give information about the total amount of SF6 contained in the GIS installation.

9.18 GIS Earthing

i) All enclosures of the GIS shall be grounded at several points and connected to ground bus. All conduits and cable sheaths shall also be connected to the ground bus available within the control cubicles and in the marshalling boxes.

ii) The three enclosures of single-phase GIS are required to be bonded to each other at the ends of GIS. The enclosure of the GIS shall be adequately grounded so as to limit the potential difference between individual sections within the allowable limit during faults.

iii) The earthing system of GIS building must be capable to carry power frequency short circuit currents (earth fault current) and high frequency currents from switching and lightning.

iv) Design of the GIS grounding system shall take in to consideration of Transient Enclosure Voltage (TEV) generated due to electric breakdown of insulating gas during fault or normal operation.

v) In addition to TEV, main circuit current shall not induce excessive currents into adjacent frames, structures, reinforcing steel or shall not establish current loops via other station equipment.

vi) Each marshalling box, local control cubicle, power and control cable sheaths and other noncurrent carrying metallic structures shall be connected to the grounding system of GIS via connections that are separated from GIS enclosures.

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9.19 GIS Switchgear

9.19.1 Circuit breakers

i) The circuit breakers shall meet the following requirements:

ii) Rated normal current of the Busbars and Feeders at the rated Voltage as stated in the single line diagram.

iii) Duration of short circuit withstand current as stated in Data Sheet A1.

iv) Capability for three pole auto-reclosing without replenishment of stored Energy as a minimum. The rated operating duty cycle sequence shall be as follows:

O - 0.3 secs. - CO - 3 min – CO

v) The maximum interrupting time at the minimum operating SF6 pressure of the mechanism shall not exceed 3 cycles (60 ms-50 Hz systems and 50 ms-60 Hz systems) for Circuit Breakers up to 245 kV class and not more than 2 cycles (40 ms-50 Hz systems and 33 ms-60 Hz systems) for Circuit Breakers above 420 kV class or as specified in Data Sheet A1.

vi) The Circuit Breakers shall have a First Pole to Clear factor of 1.5 for Circuit Breakers up to 245 kV class and shall be 1.3 (for only solidly grounded systems) for 400 kV class Circuit Breakers and above or 1.5 if specifically required as per Data Sheet A1.

vii) The total interrupting time at all currents less than the rated short circuit interrupting current shall not exceed the rated maximum interrupting time. Restrikes shall not occur under any mode of interruption.

viii) Rated small inductive current breaking: The value shall be assigned by the GIS Manufacturer having regard to the ratings and characteristics of the associated transformers/reactors and shall be supported by test reports, which shall be submitted with the Tender.

ix) The circuit breakers shall be of double interrupter design (2 breaks in series per pole) for 63 kAIC and can be of single interrupter design up to 50 kAIC and lower subject to satisfactory operation of the Circuit Breaker for Short Line Faults and Terminal Faults Test duties without the need of external devices.

x) External Line to ground capacitors or grading capacitors shall not be used to mitigate the TRV for Short Line Faults test duty. External Line to ground capacitors or grading capacitors, if used to mitigate the TRV for Short Line Faults, will have to be indicated separately and can only be accepted if specifically approved. The fixed and moving contact shall be housed in same interrupter chamber without any split so as not to affect the synchronism of three phases.

xi) However, Voltage grading capacitors may be used across contacts for double interrupter designs for 63 kAIC Circuit Breakers.

xii) The breaker shall be self-blast / auto puffer type principle and consisting of one interrupting arcing chamber. Circuit breaker must be in the independent gas compartment & no other equipment (CT/DS/ES) shall be accommodate inside CB compartment.

xiii) The breaker shall be re-strike free. Circuit breaker class shall be as indicated Data Sheet A1

xiv) Breaker disposition must be horizontal to provide higher mechanical stability and ease in maintenance. The operating principle of breaker shall ensure minimized dynamic floor loading.

xv) Single pole type circuit breakers with individual operating mechanism shall be provided with pole-discrepancy protection with time delay for tripping both trip coils (1st stage) and adjacent breakers (2nd stage) in case of discrepancy.

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xvi) Single pole type circuit breakers with individual operating mechanism shall have capability for 1-Phase and/or 3-phase auto-reclosing requirement to meet the operating duty cycle.

xvii) In addition, the circuit breaker shall comply with the following requirements as specified in the applicable standards mentioned in Data Sheet A2.

a. Rated LIWL and SIWL (applicable for Voltages above 245kV).
b. Rated Frequency
c. Rated Transient Recovery Voltage (TRV) for terminal faults and Short line faults.
d. Rated short circuit making current (at 50 Hz & 60 Hz as applicable)
e. Rated characteristics for short line faults.
f. Rated out-of-phase breaking current.
g. Rated Capacitive current switching.
h. Rated Power Frequency withstand Voltage.
i. Switching Performance Requirements

9.19.2 The breakers shall be capable of:

i) Circuit breakers installed close to large generating plant or controlling very long transmission Lines will be subjected to fault currents which may have delayed or no zero crossing for a considerable number of cycles due to a high X/R ratio of the system. The GIS Manufacturer shall propose a suitable Circuit Breaker which can mitigate the high reactive component to achieve the opening of the Circuit Breaker at current zero within the normal operating time of the breaker. The methods of demonstrating satisfactory conformance to this requirement shall be mutually agreed between the Purchaser and the Vendor.

ii) Purchaser shall furnish the Network parameters for the delayed zero passage condition, if applicable to the GIS Manufacturer after award of Contract. The GIS manufacturer shall prove by calculations and by factory tests that the Circuit Breaker can safely interrupt the fault without restrikes.

iii) Switching off unloaded overhead lines.

iv) Switching unloaded transformers without exceeding specified over voltages.

v) Cable Switching

There shall be no restrike across the main contacts when breaking capacitive or cable charging currents up to a value specified in the applicable standards mentioned in Data Sheet A2 or as specified under in Data Sheet A1.

9.19.3 Closing/Opening Resistors/Reactors (where applicable)

Closing Resistors/Reactors may be provided in special cases where applicable to limit the Inrush charging current of the breakers within its capability. Closing and/or opening resistors/Reactors shall also be provided in special cases to limit switching surges and to mitigate the TRV within the Circuit Breaker's capability. The closing/Opening Resistors/Reactors shall be provided with a bypass switch arrangement to cut in/out the Resistor/Reactor for the intended purpose only.

Closing Resistors/Reactors shall have adequate thermal capacity for the auto-reclose duty cycle.

9.19.4 Interrupter Contacts

i) Main contacts shall have ample area and contact pressure for carrying the rated current and the short time rated current of the breaker without exceeding guaranteed temperature rise.

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ii) Positive mechanism interconnection shall be provided between interrupting contacts, resistor switches (when used), blast valve mechanism, if any, to ensure maximum operating reliability.

iii) Where Two breaks per pole interrupters are used, these shall be so designed that a fairly uniform voltage distribution is developed across them. Grading capacitors across contacts may be used only to have a uniform voltage gradient across the contacts.

9.19.5 Operating Mechanism

Operating mechanism shall have following features:

i) Circuit breakers shall be operated by Spring or Hydraulic-Spring or hydraulic mechanism. Each mechanism shall be provided with its own monitoring gauges and accessories. In addition, provision for manual operation shall also be made.

ii) Operating mechanism shall normally be operated by remote electrical control. Electrical tripping shall be performed by shunt trip coils. Provision shall be made for local electrical control.

iii) A local manual closing device shall also be provided for maintenance purpose. Direction of motion of handle shall be clearly and indelibly marked.

iv) Circuit breakers shall have high repeatability of closing time over a wide range of parameters (ambient, temperature, hydraulic pressure, control voltages etc.). The time difference between first and last pole, for opening or closing shall be as follows:

a. Closing: Less than 4 msecs (60Hz) and 5 msecs (50Hz)
b. Opening: Less than 2.5 msecs (60Hz) and 3 msecs (50Hz)

v) Operating mechanism shall be suitable for Auto reclosing. It shall be non-pumping electrically and mechanically under every method of closing (except during manual closing of a breaker for maintenance). A latch checking switch shall be provided on mechanically trip free mechanisms to prevent reclosure before the breaker latches have reset.

vi) Shall be provided with two independent trip and close coils each. The tripping and opening mechanism shall function correctly when either one or both coils are energised. The close and trip coils shall be rated for the DC voltage indicated in Data Sheet A1 and shall operate satisfactorily at the designed temperature for voltage ranges between 85% to 110% rated voltage for closing coil and 70% to 110% for tripping coils. However, in some specific cases the trip coil may be required to operate with a different voltage range, which will be as specified in Data Sheet A1.

vii) A mechanical indicator shall be provided to indicate open and closed positions at a location from where it will be visible to a person standing on the floor. An operation counter shall also be provided. Separate counter shall be provided on each phase for a segregated system.

viii) The circuit breaker mechanism shall be mechanically trip free. The Circuit Breaker shall also be provided with an Anti-pumping feature.

ix) The trip coil shall be suitable for trip circuit supervision during both open and close position of breaker.

x) Working parts of the mechanism shall be of corrosion resisting material. Bearings which require grease shall be equipped with pressure type grease fitting. Bearing pin, bolts, nuts and other parts shall be adequately pinned or locked to prevent loosening or changing of adjustment with repeated operation of the breaker.

xi) Provision shall be made for attaching an operation analyser to perform CB timing tests after installation of the breakers.

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xii) Interlocks and/or blocking device shall be provided to prevent hunting and dangerous or undesirable operations of the circuit breaker.

9.19.6 Spring and Hydraulic-Spring Operated Mechanism

i) The operating mechanism shall be motor-compressed spring-operated, or hydraulic/hydraulic-spring charged. Single pole circuit breaker employing single-pole operating mechanism shall be electrically coupled for synchronous three-pole operation.

ii) Motor-compressed spring-operated mechanism shall employ a motor for the rated AC/DC Voltage for spring charging. The energy storage of a motor compressed spring-operated circuit breaker shall be sufficient for an open-close-open operation without replenishing the stored energy. Means shall be provided to prevent overcharging of spring. Mechanical indication of spring(s) for both "charged" and "discharged" states shall be provided. Provision for manual spring charging shall be provided, which shall automatically cut-off the power supply to the motor during manual charging.

iii) Spring charging motors shall be suitable for operation at any voltages between 85% and 110% of rated auxiliary voltage.

iv) The capacity of energy storage facilities that are integral part of the hydraulic/hydraulic-spring operating mechanism shall be sufficient to permit at least full rated duty cycle of the breaker without replenishing the stored energy. A hydraulic pressure gauge shall also be provided. Oil used in the hydraulic/hydraulic-spring mechanism shall be free of PCB.

v) Closing action of circuit breaker shall compress the opening spring ready for tripping.

vi) When closing springs are discharged after closing a breaker, closing springs shall automatically be charged for the next operation and an indication of this shall be provided in the local control cabinet & SAS.

vii) Provisions shall be made to prevent a closing operation of the breaker when the spring is in the partial charged condition

viii) Mechanical interlocks shall be provided in the operating mechanism to prevent discharging of closing springs when the breaker is in the closed position.

9.19.7 Hydraulic Operated Mechanism

i) Hydraulic operated mechanism shall comprise of self- contained operating unit with power cylinder, control valves, high- and low-pressure reservoir, motor etc. The manual operation shall be interlocked with auto-operation by blocking it to ensure safety to the operator.

ii) The oil pressure switch controlling the oil pump and pressure in the high-pressure reservoir shall have adequate no. of spare contacts, for continuous monitoring of low pressure, high pressure etc. at switchyard control room.

iii) The Design shall be such that it shall be possible to perform at least two close-open operations after failure of AC supply to the motor.

iv) The mechanism shall be capable of operating the circuit breaker correctly and performing the duty cycle specified under all conditions with the pressure of hydraulic operated fluid in the operating mechanism at the lowest permissible pressure before making up.

v) Trip lockout shall be provided to prevent operations of the circuit breaker below the minimum specified hydraulic pressure. Alarm contacts for loss of Nitrogen shall also be provided.

vi) All hydraulic joints shall have no oil leakage under the site conditions and joints shall be tested at factory against oil leakage.

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vii) Controlled Switching Device (CSD) and Pre-Insertion Resistors (PIR)

viii) Circuit breakers of 400kV and above voltage class shall be provided with Controlled Switching Devices (CSD) as a tool for minimizing switching transients and inrush currents in 400kV and above voltage class transformers and reactors.

ix) Circuit breakers of 400kV and above voltage class shall be provided with Pre-Insertion Resistors (PIR) for controlling switching overvoltage on lines of length more than 200 km.

x) Controlled switching device with consequent optimization of switching behaviour, when used in,

a. Switching of Transformer

b. Switching of Shunt Reactor

Control Switching Device shall be supplied if specified in Single Line Diagram/ Data Sheet A1/ Bill of Materials.

9.19.8 The controlled switching device shall

i) Be designed to operate correctly and satisfactorily with the auxiliary AC & DC voltages and frequency as specified in Data Sheet A1.

ii) Meet the requirements of applicable standards regarding HF disturbance test, fast transient test and insulation test.

iii) Have functions for switching ON and OFF the circuit breakers.

iv) Get command to operate the breakers manually or through auto re-close relay at random. The controller shall be able to analyze the current and voltage waves available through the signals from secondaries of CTs & CVTs for the purpose of calculation of optimum moment of switching the circuit breaker and issue command to circuit breaker to operate.

v) Have an adaptive control feature to consider the next operating time of the breaker in calculation of optimum time of issuing the switching command. In calculation of net operating time of the breaker the controller must consider all factors that may affect the operating time of the breaker such as, but not limited to, ambient temperature, control voltage variation, SF6 gas density variations etc. Schematic drawing for this purpose shall be submitted for approval. The accuracy of the operating time estimation by the controller shall be better than + 0.5ms.

vi) Have communication port to facilitate online communication of the control switching device with SCADA directly on 61850 or through gateway.

vii) Be PC compatible for the setting of various parameters and down loading of the settings and measured values date time of switching etc. Window based software for this purpose shall be supplied.

viii) Have self-monitoring facility.

ix) Be suitable for current input of 1/5 amp from the secondary of the CTs. and 110 V (Ph to Ph) from the CVTs. The controller shall also take care of transient and dynamic state values of the current from the secondary of the CTs and CVTs.

x) Have time setting resolution of 0.1 ms or better.

xi) Have sufficient number of output/input potential free contacts for connecting the monitoring equipment and annunciation system available in the control room.

The CSD shall also record and monitor the switching operations and adjust the switching instants to optimize the switching behaviour as necessary. It shall provide self-diagnostic facilities, signalling of alarms and enable downloading of data captured from the switching events.

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The provision for bypassing the Controlled switching device shall be provided through remote. Wherever, the controller is not healthy due to any reason (Including Auxiliary Supply failure), uncontrolled trip, close command shall be extended to the Circuit Breaker. Alternatively, in case of any non-operation of the controlled switching device after receiving a close/trip command after a pre-determined time delay, the controlled switching device shall be bypassed so as to ensure that the trip and close commands are extended to the Trip/close coils through subsequent command.

CSD closing and opening command shall be connected to DC source-1, however if DC-1 source is failed operation of CSD shall be performed through DC-2 source. Necessary change over circuit to be provided for the same.

9.20 Disconnect switches and Ground switches

i) The disconnect and grounding switch shall be Motorized, three (3) pole gang operated, no-load break, single stroke type, and shall generally comply with the requirements of the applicable standards mentioned in Data Sheet A2.

ii) The disconnect switch shall fully comply with the specified requirements of insulation level for the isolating distance as stated in the applicable standards mentioned in Data Sheet A2.

iii) The disconnect switch shall be capable of interrupting rated capacitive currents originating from switching busbars, busducts and very short lengths of cable and inductive currents as specified in the data schedule as per the applicable standards mentioned in Data Sheet A2.

iv) The busbar side disconnect switches shall be capable of switching rated Bus-Transfer switching currents (Bus side Disconnects of each bay for Double Bus schemes) as per the applicable standards mentioned in Data Sheet A2.

v) The disconnect switches shall be equipped with adjustable, self-aligning, high pressure type silver-faced copper contacts. The contacts shall be capable of carrying full rated and short circuit currents without over heating or welding. Contact design shall be such that no shunt current shall flow through the contact springs.

vi) Grounding switches shall be high-speed type at Line entrance and maintenance type for bay grounding. Maintenance type Bus Grounding switches shall be provided for each bus of the GIS.

vii) The grounding switches shall be equipped with snap spring-operated high speed operating mechanism with provision for manual operation.

viii) Continuous current rating of the High-speed grounding switches shall be specified by the manufacturer, which can be safely injected for Bay/ Bus equipment testing.

ix) The High-speed grounding switches shall be fitted with a stored energy closing system to provide fault making capacity

x) The switches shall have inductive/ capacitive current switching capacity as per applicable standard.

xi) Termination point grounding switches shall be capable of closing against the rated short circuit making current of the switchgear. All grounding switches shall have the same short time current rating as that of the switchgear.

xii) In all grounding switches, the ground connection of each phase shall be isolated from the ground connection of the other phases and from the switchgear enclosure, and brought out through an insulated bushing, rated 10kV minimum. Direct connection to ground shall be via a removable grounding strap. The current rating of the removable grounding strap shall be equal to that of the grounding switch.

xiii) The line grounding switches installed at each termination point of GIS shall be capable of breaking the induced capacitive and inductive currents as per the applicable

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standards mentioned in Data Sheet A2 (Class B) considering the transient recovery switching duty imposed on the ground switch.

xiv) All disconnect and grounding switches shall be equipped with local as well as remote controlled power-operated mechanism. An emergency manual operating device shall also be provided. DC power supply to the mechanism shall be automatically disconnected and local/remote electrical operation shall be prevented when manual operating device is engaged. The power to disconnect and grounding switch in the enclosure shall be transmitted via gas-sealed pressure-resistant shaft glands. Once initiated, the motor mechanism shall complete an open or close operation without requiring the initiating contact to be held closed.

xv) The disconnect and grounding switches shall be provided with pad - locking facilities to permit locking both in open and closed positions.

xvi) All disconnect and grounding switches shall have mechanical position indicators for the main contact movements, directly coupled to the driving shaft and clearly visible from outside.

xvii) Inspection windows/endoscopy ports shall be provided in the housing of each disconnect and grounding switch to ensure isolating distance or gap by observing the position of each movable contact. The inspection viewports shall have removable covers to prevent damage of the actual viewport due to external elements. Access to viewports/endoscopy ports shall be convenient. A warning plate (green or white background with black lettering) shall be installed near each viewport/endoscopy port to warn (with words: WARNING—DO NOT LOOK INTO THE VIEWPORT DURING SWITCHING OPERATION. ARCING MAY DAMAGE YOUR EYES) of possible danger when viewing the interior during switching operation. The area around the viewport/endoscopy port shall be painted by a distinctive colour as a warning (orange or yellow).

xviii) Anti-condensation heaters shall be provided within the housing of each motor driven operating mechanism.

xix) Interlocks

a) Electrical and Mechanical interlocks shall be provided for absolute and positive protection against potentially harmful mal operations of the switchgear. Electrical interlocking shall be fail-safe type. Consultant or Owner's requirement shall be also taken while finalizing scheme.

b) Disconnect Switch and Grounding switch shall be mechanically interlocked such that it will not be possible to close the Grounding switch when the Disconnect Switch is closed or vice-versa.

c) For the design where both are operated via separate drives, pad locking type interlocks shall be provided in addition to the electrical interlocking facility.

d) Disconnect Switch shall be provided with electrical interlocking feature. This shall be in the form of bolt interlock comprising an interlock coil of latch-in type to lock the Disconnect Switch driving shaft and hence prevent Disconnect Switch operation in the latch-in condition. It shall be possible to release the latch by energising the interlock coil only when all the conditions of safe operations are satisfied. Facilities shall be provided for wiring Purchaser's external interlocks in Disconnect Switch opening and closing circuits for this purpose.

e) Crank handle insert shall prevent the operation of isolator & earth switch within the entire bay. Crank handle inserted alarm to be annunciate in local and remote.

xx) Short Circuit Withstand Capacity

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a) The rated peak short-circuit current or the rated short time current carried by a Disconnect Switch or Grounding switch for the rated maximum duration of short circuit shall not cause:

- Mechanical damage to any part of the Disconnect Switch or Grounding switch.
- Separation of the contacts or contact welding.
- Excessive temperature rise which is likely to damage insulation.

b) After the passage of these currents, the Disconnect Switch shall be able to carry its rated current under specified conditions and the operation of the operating device shall not be impaired.

c) Where a Grounding switch is combined with a Disconnect Switch as a single unit, the rated peak short circuit current and the rated short time current of the Grounding switch shall be at least equal to those specified for the Disconnect Switch.

xxi) Auxiliary Switches

a) Each circuit breaker, disconnect, and grounding switch shall be provided with mechanically direct driven auxiliary switches. These auxiliary switches shall be provided with minimum six (6) normally open (NO) and six (6) normally closed (NC) Directly driven spare auxiliary potential-free contacts and six (6) normally open (NO) and six (6) normally closed (NC) multiplied spare potential free contacts in addition to those required for the operating mechanism control and indications, protection and interlocks with other equipment. For bus side Disconnectors suitable for bus transfer duty, early make late break type contacts shall be provided for bus bar differential protection.

b) Auxiliary switches shall be rated for 10A, DC 250 volts. Adequate number of Auxiliary switch contacts (Directly driven and multiplied) shall be provided.

c) Directly operated, electrically separate, reversible and adjustable type auxiliary switches shall be provided on breakers, disconnect switches and ground switches in quantities as required for the Project.

d) All tripping and interlocking schemes shall use directly driven contacts of the Circuit Breaker, Disconnect and ground switches.

e) Alarm, trip and spare contacts from operating mechanism shall be wired to the local control panels. Alarm and trip contacts to be used for Remote Control panel should be connected to terminal blocks.

f) 10 % Spare Auxiliary contacts completely wired up to the Terminal blocks in Local Control Panel shall be provided.

9.21 Instrument Transformers

i) General Requirements

a) Terminal and polarity marks shall be indelibly marked on each VT & CT on the associated terminals and these marks shall be in accordance with relevant standards and as per Client's requirement.

b) It shall be possible to test each current transformer without removal of gas through insulated grounding switches

c) Provision shall be made for primary injection testing either within CT or outside

d) There should be facility to mount current transformer on either side of circuit breaker

e) Secondary terminals of each voltage and current transformer shall be brought out in a weather-proof local control cabinet. Facilities shall be provided at the control

cabinet for isolation and testing of CT secondaries. The design of isolated phase type CT's shall protect them from effects of enclosure current. Facility shall be provided for shorting and grounding the CT secondary at the terminal box. The star point, whenever required, shall be formed at the terminal box only.

f) Two Grounding terminals for connecting the specified size of Grounding conductor.

- Terminals for Tan Delta measurement. These terminals under service conditions shall be connected to Grounding by means of links.
- Voltage and current transformers shall be provided with the following accessories:

ii) Voltage Transformers

All Voltage Transformers shall conform to the applicable standards mentioned in Data Sheet A2 in general

a) Voltage transformers shall be of single core type, metal enclosed, gas insulated, electro-magnetic, mounted directly on the high voltage enclosure with plug in contacts that allow easy removal. The VTs shall be 5 limb type or 3-Single phase units in case of a common 3 phase enclosure.

b) Minimum accuracy, burden and transient response characteristics shall be as specified in the single line diagram.

c) In case of ungrounded voltage transformers both the terminals of the primary winding shall be brought out through bushings rated for full line voltage. In case of Grounded voltage transformers, the end of the primary winding intended to be grounded shall be brought out through a bushing and Grounding connection shall be made outside.

d) The secondary terminal box for the voltage transformers shall also include necessary HRC fuses/ MCBs (Preferably MCBs) for protecting the secondary circuit. Further, for the purpose of fuse supervision both terminals of fuse shall be brought out to the terminal box. MCBs shall be provided with auxiliary contacts for interlocking, Trip and alarm purposes.

e) Whenever a VT secondary winding is used for both measurement and protection application it shall have dual accuracy class of 0.5/3P, unless otherwise specified. However, for revenue class metering applications the accuracy class shall be 0.2 for that core or as per Utility requirements.

f) The Voltage Transformer shall be so designed to avoid ferro resonance effects and shall be provided with adequate ferro resonance-suppressor (if required) on the secondary windings. An electrostatic shield shall be employed between the windings of VT to prevent coupling of the transients generated in the GIS high voltage conductors with the control wires.

g) Voltage Transformers shall not be mounted on the same compartment/Gas section as the Cable Feeder termination compartment in order to test the Cable feeder independent of the Voltage Transformer.

h) All GIS electromagnetic Voltage Transformers shall have primary isolation device manually operated and monitored at local (LCC) and remote (control room) on the mimic diagrams.

i) Voltage transformer shall be attached to gas insulated system such a manner that they can be readily disconnected from the system by operating Isolator (offline) / disconnector switch to isolate the VT is required for dielectric testing.

iii) Current Transformers

a) Number and location of CTs.

- The ratio, burden, accuracy class, knee point voltage etc. shall be provided as specified in the single line diagram. CTs and PTs adequacy check shall be done based on the connected relaying and instrumentation load.
- The physical relative location of core in the CTs should be in accordance with the locations shown in single line diagrams enclosed with the Tender enquiry to ensure over lapping of protective zones. CTs shall be preferably located outside of circuit breaker chamber.

b) Minimum Accuracy for Relaying Cores

All Current Transformer cores shall conform to the applicable standards mentioned in Data Sheet A2 in general and the applicable standards mentioned in Data Sheet A2 for Transient Protection Class CTs.

(a) Accuracy Class 5P20, Class PX, Class TPS etc and class 0.2/0.2S for revenue metering as required shall be provided as specified in the single line diagram.
(b) Current Transformers may be single/dual/Multi Ratio type (MRCT) as specified in the Relaying and Metering Single Line diagram.
(c) For the purpose of polarity checking, the position of each primary terminal in the current transformer SF6 gas section shall be clearly marked.
(d) In the case of multi core CTs, it shall be possible to adjust the ratio taps on any core independent of the setting on the other cores, for which purpose these tapings shall have to be provided on the secondary windings only.
(e) All CT cores shall be of low reactance type.
(f) No turns compensation shall be used in case of 'Class TPS or Class PX CTs. Turns compensation, if any, shall be clearly brought out in the Bid in Data Sheet B.
(g) In case of multi ratio CTs, the minimum specified requirements in respect of VA, accuracy, and Knee Point Voltage (Vkp) and maximum secondary resistance shall be applicable at the taps underlined in relevant drawings enclosed with the Tender.
(h) Magnetizing characteristics (extending well beyond Vkp) and secondary impedance values shall be furnished in Data Sheet – B for all protection cores.

9.22 GIS Surge Arresters

i) SF6 Insulated GIS Surge arresters shall be provided in the switchgear equipment for limiting any system transient voltages during switching and/or fault conditions in the system, if deemed necessary as per calculations. The location of the surge arrester shall be in accordance to the single line diagram. The surge arresters shall fully comply with the applicable standards mentioned in Data Sheet A2.

ii) The surge arresters shall be housed in enclosures mechanically separated from the other GIS parts by means of a gas barrier insulator. Each single-phase surge arrester and enclosure shall be treated as a single gas-monitoring zone.

iii) The base plate of the enclosure shall be provided with a bushing type facility to permit leakage current measurements and the addition of discharge counters for purpose of monitoring the frequency of discharges.

iv) Surge arresters if specified in Data Sheet A1 shall be provided as part of GIS.

9.23 SF6 to Air Bushings

i) SF6 to Air Bushings shall conform to the applicable standards mentioned in Data Sheet A2 and shall have an impulse and power frequency withstand level that is greater than or equal to the level specified for the GIS.

ii) SF6 to Air Bushings shall have minimum creepage as specified in Data Sheet A1. All creepage requirements shall be calculated on the basis of rated Line-to-Line Voltage.

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iii) Bushing shall be suitable for hot line washing and shall be provided with "water cut sheds".

iv) Puncture strength of bushings shall be greater than the dry flash-over value. When operating at normal rated voltage, there shall be no electric discharge between the conductors and bushing which would cause corrosion or injury to conductors, insulators or supports by the formation of substances produced by chemical action. No radio interference shall be caused by the bushing when operating at the normal rated voltage.

v) All hardware used for current carrying parts shall be SS 304 and other iron parts shall be hot dip galvanized.

vi) All joints shall be air tight. Surface of the joints shall be turned up; porcelain parts by grinding and metal parts by machining. Bushing design shall be so as to ensure uniform compressive pressure on the joints.

vii) All current carrying contact surfaces shall be silver faced.

viii) GIS Manufacturer shall furnish details of precaution taken to prevent bimetallic corrosion wherever dissimilar materials (such as Copper, Aluminium) are used, including the following:

a) Aluminium conductor in the bus duct and the current carrying part in the bushing.

b) Terminal clamp and the current carrying part in the bushing if bushing stud is not of Copper.

9.24 GIS Terminations

The following type of terminations shall be made, as applicable where SF6 Gas Bus duct directly connect the feeders provided in the GIS with the external Cables/Overhead Lines, Power Transformers, Shunt Reactors, Shunt Capacitors etc.

i) **Sealing End Box For GIS To XLPE Cable Termination**

a) Suitable SF6 gas-filled cable sealing end boxes shall be provided, where required, for accommodating XLPE single core copper cable terminations. The boxes shall be designed to accept the cable along with its terminations cone from below. The scope shall also include necessary cable supports and cable grounding facilities.

b) Necessary data about the power cables required for designing/supplying suitable cable terminations are as specified in Data Sheet A1.

c) The cable connections shall comply with the applicable standards mentioned in Data Sheet A2.

d) The SF6-to-XLPE Cable at the power cable pothead termination shall allow for power cable disconnection from the gas-insulated bus through a removable link and provide means to permit High Voltage AC field testing of the cable.

e) Effective and long-life gas-tight seals shall be provided between the cable sealing end and the cable termination enclosure. It shall be possible to accommodate high voltage cables of all types up to 2500mm2 conductor cross-section at the cable end terminations.

f) The design of the cable termination shall allow plugging and unplugging the EHV cable without need of opening the GIS and without any gas work or minimum work.

g) All the GIS apertures intended for future cable terminations shall be sealed with effective cover plates to safeguard against SF6 leakage.

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h) Wherever necessary the cable enclosure and support structure shall be equipped with means for isolating the cable sheath to provide cathodic protection of the cable system per the applicable standards mentioned in Data Sheet A2.

i) SF6 Gas Pressure Switch shall be provided for monitoring.

j) Cable sealing ends shall be indoor or outdoor as specified in Data Sheet A1.

ii) **SF6-to-Air Overhead Line Termination**

a) For connecting overhead lines with the GIS, SF6-to-Air outdoor bushings, mounted on suitable steel structures shall be installed. The bushings shall be wet processed porcelain or Composite (SiR) Insulator bushing and shall generally conform to the applicable standards mentioned in Data Sheet A2. The bushings shall have adequate Mechanical strength to withstand the Short circuit forces, Wind force and loading for the type of connection.

b) The SF6-to-Air terminations shall include all necessary materials such as SF6 busduct, gas monitoring devices, busbar extensions, removable links to ensure complete termination.

c) SF6 Gas Pressure Switch shall be provided for monitoring.

d) The SF6-to-Air termination shall be provided with bursting/rupture disc. To obtain the necessary air clearance at the outdoor terminals, the bushings shall be splayed using suitable shaped enclosure section.

iii) **SF6-To-Oil Transformer Termination**

a) Gas tight seals shall be provided between the duct enclosure and the SF6-to-Oil bushing.

b) All such GIS apertures intended for future use shall be provided with gas tight cover plates.

c) SF6 Gas Pressure Switch shall be provided for monitoring.

d) The termination apertures shall be matched with the transformer dimensions. SF6-to-Oil transformer terminations shall include all necessary materials such as SF6 busduct, gas monitoring devices, busbar extensions, removable links, bellow assembly, flexible interconnecting copper straps to minimize vibration transfer from the transformer, and supporting structures, etc., to ensure complete termination. The bellows shall be self-compensated or compensated in compression by tie-rods, springs.

e) The SF6-to-oil bushing at the Power Transformer termination shall allow for disconnection from the gas-insulated bus through a removable link and provide means to permit field testing of the Transformer at the point of connection.

9.25 Local control panels and mechanism cabinets

9.25.1 General

General features shall be as follows:

i) Standalone Control panel shall be dead back type, sheet steel enclosed with degree of protection of IP 43 suitable for mounting close to the wall. Sheet steel used shall be cold rolled and at least 2.0 mm thick. Door shall have key locking facility or provision for padlocking.

ii) All control equipment shall be suitable for operating in an ambient temperature varying between 00 C and + 50°C. For Outdoor installations, the ambient temperature variation shall be between –5 °C to + 600 C with a Relative Humidity of 100%.

iii) A Ground bar for terminating the Ground wires of shielded control cables shall be located near the cable entry location.

iv) All control Panels and Marshalling Cabinets shall be provided with Anti-Condensation heaters which are thermostatically controlled. These Heaters shall operate on 1-phase, 240 V AC. The thermostat-controlled heaters shall be provided complete with rotary type ON/OFF switch, HRC fuses or single pole MCB with overload and short circuit protection, link on neutral. Provision for monitoring of heater failure shall be provided for all heaters.

v) A LED fixture with door switch and one 6 pin 240V AC, 5/15 A Duplex receptacle shall be provided in each cabinet.

vi) The accessories and auxiliary equipment required for the correct functioning of each circuit element shall be installed in conveniently located mechanism cabinet (s).

vii) The interior shall be painted glossy white and exterior paint shade shall be 693 as per the applicable standards mentioned in Data Sheet A2, unless specified otherwise.

viii) Terminal blocks of approved type shall be provided. Terminal wiring shall be accessible from the front side of the panel.

9.25.2 Local control panel

i) Individual local control panels for each circuit shall be supplied to facilitate local control of circuit breakers, disconnectors and Ground switches. These panels shall also house the various relays, timers etc. to realize specified interlock requirement among circuit breakers, disconnects and Ground switches. The contacts, signals and conditions originating from/ going to the switchgear, associated auxiliary, monitoring equipment and CT/VT wiring from the terminal boxes shall be wired up to the local control panels. Bay Control Unit shall be provided in the LCP for control and indication purpose while interfacing with SCADA/SCS to reduce the hardwiring if specified in Data Sheet A1. BCU's shall be placed in an air-conditioned environment.

ii) Completely separate and isolated circuit shall be used for operating mechanism control, tripping alarms and auxiliary devices. CLOSE and TRIP circuits shall be kept isolated to their final mechanical or electrical actuators. Trip circuits shall have individual monitoring facilities.

iii) Low Voltage AC/DC Switches/ MCBs

a) Switches/MCBs shall be hand operated, air break, heavy duty, quick make, quick break type conforming to applicable clauses as per the applicable standards mentioned in Data Sheet A2.

b) Switch handle shall have provision for locking in both fully open and fully closed positions. MCBs shall preferably be provided with suitable locking facility.

c) Single throw isolating switches for complete isolation of the DC control circuits shall be provided.

d) Control switches shall be of the rotary type provided with properly designated escutcheon plates clearly marked to show the operating positions. Control switches shall have momentary contacts, spring return to normal, with pistol grip handle. Selector switches shall have stay put contacts with oval handles. The local/remote selector switch shall be lockable in both positions. The number of contacts and their operation in each switch position shall be as per the requirements of the connected circuit. The switches shall be rated for minimum 10 A at 240 AC and 1 A inductive break at specified DC voltage.

9.25.3 Control & Auxiliary Power Supply

i) For alarm, auxiliary devices, annunciation and indication, separate control supply feeder shall be provided by the Purchaser to each Local Control Panel.

ii) All control equipment shall be suitable for operation on specified DC system.

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iii) Separate circuits with switches, fuses/MCB, etc. of adequate rating shall be provided for control of space heater, lighting and power receptacle. These shall be on 240 V, single phase AC supply, unless specified otherwise.

iv) AC and DC power supply shall be such that isolation of individual equipment is possible.

v) AC & DC auxiliary supply to be supervised and any failure of the same to be annunciate in local & potential free contacts to be provided for remote monitoring.

9.25.4 Relays

i) Relays for various control, monitoring and blocking functions of particular circuit element shall be installed in associated local control panel.

ii) Necessary auxiliary relays for alarm, time-delay relays, voltage relays as required for control and protection shall be mounted inside the local control panel. Voltage operated relays shall have sufficient thermal capacity for continuous energisation

iii) Auxiliary relays shall be rated to operate satisfactorily between 80% and 110% of the specified rated voltage.

iv) Each relay shall be provided with at least 2 NO and 2 NC potential free contacts, wired up to terminals for Customer's use.

v) Coils of all the relays shall be adequately rated to avoid spurious operation of relays on D.C. system ground or induced surges.

vi) All relays shall be tropicalised and shall be suitable for design ambient temperature as specified in Data Sheet A1.

vii) Make and type of relay shall be subject to approval of the Purchaser.

viii) Relays trip contacts connected for trip circuit shall have the making capacity of 30 amp for 0.2 seconds with an inductive load of L/R > 10 mill seconds. Bidder to submit the relay catalogue for approval

ix) Contact multiplication relays shall be provided for Gas Monitoring, Pole Discrepancy and if any alarms

x) Electrically reset latch type trip relay shall be provided for SF6 Gas low zone trip stage. The operating time of the same shall not be more than 10 milliseconds. Provision for reset from remote to be provided

9.25.5 Push Buttons

i) All push buttons shall be of push to actuate type having 2 NO and 2 NC self-reset contacts. They shall be provided with integral escutcheon plates, engraved with functions. Push button contacts shall be rated for 10 A at 240 V AC and 1 A inductive breaking at specified DC voltage.

ii) Indicating Lamps

iii) Cluster LED type indicating lamps shall be provided.

9.25.6 Internal Wiring

i) Cabinets/Panels shall be supplied completely wired ready for external connections at the terminal blocks. All wiring shall be carried out with cable shielded from electrostatic and electromagnetic interferences as per IEC and having wires of 600 V grade, stranded copper conductors. The insulation shall be halogen free and flame retardant. Power circuits shall be wired with stranded copper conductors of adequate sizes to suit the rated current and the minimum size shall be 4 sq.mm. Unless otherwise specified, control alarm and indication circuits shall be wired with stranded, tinned copper conductors of sizes not smaller than 1.5 sq.mm. CT and VT circuits shall be wired with stranded copper conductor of size, not smaller than 2.5 sq.mm.

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ii) Engraved identification ferrules, marked to correspond with the wiring diagram shall be fitted at both ends of each wire. All wiring shall be terminated on terminal blocks. Terminals shall be adequately rated for the circuit current, minimum rating shall be 10A. Control wiring shall be protected against mechanical damage.

iii) CT/PT terminals shall be of disconnecting links types and all other terminals shall be of stud type. CT terminals shall have shorting and Grounding facility.

iv) The wire terminations shall be made with solderless crimping type of tinned copper lugs.

v) Wiring shall be colour coded and be firmly supported, neatly installed by lacing and taping, readily accessible and connected to equipment terminals and terminal blocks. Halogen free, flame retardant plastic wiring channels/troughs with strap on covers shall be used for this purpose.

vi) All control & instrument cable terminations shall have double compression type cable glands with shield grounding provision and shielded from electrostatic and electromagnetic interferences as per IEC.

9.25.7 Mimic Diagrams

i) Mimic diagrams shall be provided on local control panels. The mimic strips shall be made of anodised aluminium and shall be screwed onto the panel. Colours of the various voltages of the mimic bus shall comply with relevant IEC standard. The width of mimic strip shall not be less than 5 mm. Discrepancy switches and semaphore indicator shall be provided on the mimic diagram as applicable.

9.25.8 Local Alarm/Annunciation

i) Window type Alarm/Annunciation shall be provided on local control panels of each bay for annunciating the specified abnormal conditions related to the bay covering SF6 gas pressure conditions, control supply fail as well as the hydraulic operating mechanism. The alarm windows shall have provision for differentiating cleared and uncleared faults and flashing for new faults. The Alarm/Annunciator system shall be provided with First out feature.

ii) Alarm circuit shall not respond to faults for momentary conditions. The following minimum indications shall be generally provided in the alarm and indication circuits.

a) Low Gas Pressure Stage-1, 2 (as applicable).
b) Low Operating Pressure / Spring Discharged (as applicable)
c) Loss of Heater power.
d) Auxiliary Power Supply Failure (AC, DC-1 & DC-2).
e) Pole Discrepancy.
f) Other trouble alarms for CB, DS, and any others.
g) DS/ES Drive Door Open

iii) Alarms to be made available to HMI at control room.

9.26 Mechanism Cabinets

9.26.1 The Circuit breaker mechanism cabinet shall consist of the following:

i) Circuit breaker position indicator

ii) Operation counter

iii) Provision for connection of time travel recorder

iv) Operating and monitoring device associated with circuit breaker operating mechanism shall be wired to terminal blocks in circuit breaker mechanism cabinet and further to terminal blocks in local control cabinet.

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v) Monitoring and indication devices for the status of the stored energy of the circuit breaker or other status of the operating mechanism.

9.26.2 Disconnect Switch and Grounding switch mechanism cabinet.

The mechanism cabinet, in addition to other components or accessories the GIS Manufacturer considers necessary for safe and reliable operation, shall incorporate the following:

i) Disconnect /Grounding switch position indicator

ii) Auxiliary switches

iii) Terminal blocks

iv) Operating and monitoring device associated with Disconnect /Grounding switch operating mechanism shall be wired to terminal blocks in isolator mechanism cabinet and further to terminal blocks in local control cabinet.

v) Monitoring and indication devices for the status of the operating mechanism.

9.27 Labels and Diagram Plate

i) Every GIS equipment and devices mounted in the cabinet/ control panel shall be provided with individual labels with equipment designation/ rating. Also, the cabinet/ control panel shall be provided on the front with a non-rusting label engraved with the designation of the cabinet/control panel.

ii) As built copy of a circuit diagram shall be fixed inside the door.

9.28 Miscellaneous requirements

9.28.1 Grounding

i) The GIS shall be bonded to the "Main Ground Bus" for the specified short circuit current magnitude and duration.

ii) It shall be the responsibility of the GIS manufacturer to provide a sufficient number of Ground connection points on the GIS which shall be suitable for interconnection.

iii) Provision shall be made for future extension and/or bonding to ground bus(es) of other switchgear.

iv) Every section of the SF6 switchgear equipment including all panels, cubicles, kiosks and boxes shall be solidly bonded to the Grounding system, by at least two independent leads. Two Grounding pads shall be provided at each equipment for the connection to Grounding system.

9.28.2 Grounding tester

As an additional measure for the safety of personnel it shall be possible to ascertain that the particular section of the plant is de-energised before a Ground switch is closed onto the conductor. A capacitive tap shall be provided on each gas section. One loose instrument common to the complete plant, shall be supplied for connection to a capacitive tap to indicate whether the circuit is live or dead. Provision of tap to indicate status – live or dead, capacitive taps and the instrument shall be optional and quoted for separately. Required electrical interlock with VT secondary shall also be provided to ensure that the feeder/bus is dead.

9.28.3 Welding/casting nuts and bolts

i) All welding/casting shall conform to the requirements of relevant IEC standards.

ii) At least 10% of all welds/casting shall be subjected to non-destructive testing by X rays or ultrasound and all records there of shall be made available upon request.

iii) All welding shall be performed with suitable submerged-arc welding machines or by fully certified welders.

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iv) Drawings submitted for approval shall indicate following information in respect of welds:

a) Type of weld

b) Procedure employed

c) Inspection applied

d) Applicable standard

v) Details of bolt sizes and threading shall be clearly shown on the appropriate drawings. Where self-locking type of nuts are used, they shall be of the re-usable type. Pressed type nuts are not acceptable. Fasteners used for current carrying parts shall be of Stainless Steel - 304.

vi) GIS Manufacturer shall indicate the type of protection needed and precautions to be taken during GIS installation to prevent moisture or dirt entering the enclosures.

9.28.4 Seismic qualification

i) The GIS shall be designed to safely withstand the seismic forces as per the codal design wherever applicable. The two seismic ground motion levels are 0.5g peak or 0.2g peak acceleration.

ii) GIS Manufacturer shall submit type test certificates, if applicable to prove seismic withstand capability. If identical GIS is not tested in the past, successful GIS Manufacturers shall furnish design calculation or carry out testing to prove seismic withstand capacities without cost and time implication to the Purchaser.

9.29 Special tools

i) The GIS manufacturer shall include the supply of all the SF6 gas necessary for initial filling (including usual losses during commissioning.) and putting into commercial operation of the complete switchgear. In addition, ten percent of the total SF6 gas required for the complete GIS shall also be supplied as spare in non-returnable containers in ready to use condition and shall be included in the scope of supply. The pump shall be suitable to fill up gas cylinders upto 50 Bar pressure.

ii) If specified, a mobile SF6 gas treatment plant, which shall be suitable for draining, filtration/purification and refilling the equipment shall be provided. The plant shall have storage capacity for at least two of the largest switchgear compartments and shall be supplied with complete accessories such as vacuum pump, pressure gauge, valves, hoses, couplings, adaptors, etc., necessary for evacuating and filling, together with storage facilities for these items.

iii) A two-wheel gas maintenance cart fitted with a cylinder of SF6 gas, a vacuum pump, a vacuum and pressure gauge and all necessary valves, hoses and couplings for evacuating and filling the switchgear.

iv) A SF6 Gas maintenance cart, which shall be easily moved by One person, shall be provided with enclosed storage facilities for proper storage of cylinders and other accessories including power leads. The enclosed storage shall have facilities for padlocking.

v) Connecting pipes with adaptors shall be supplied along with the cart with a spare set. The lengths shall be enough to use the gas handling plant at least 3 bays away from the bay being worked upon.

vi) SF6 gas leakage test equipment shall be suitable for testing SF6 gas as per recommendations of the applicable standards mentioned in Data Sheet A2.

a) Instruments for automatic and continuous monitoring for the presence of SF6 gas in the atmosphere of the switchgear room shall be provided if required as per Data Sheet

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A1. The recommended positions, exact number of detectors, type of mounting, facilities for alarm etc. shall be indicated in the Bid.

b) Each set of analyser shall comprise of:

- SO2 content in SF6 gas
- Purity of SF6 gas
- SF6 gas moisture content
- HF, CF4

vii) All special tools required for the purpose of installation, maintenance, overhauling, handling of toxic gases in circuit breaker chamber and testing of GIS and for the measurement of moisture in SF6.

9.30 Testing

9.30.1 Routine Tests

i) The switchgear and its component circuit breakers, Disconnect Switches, Grounding switches, SF6/oil interface bushings and instrument transformers etc. shall be fully routine tested in accordance with current edition of the relevant IEC standards.

ii) The tests may be witnessed by Purchaser's personnel. Purchaser shall be notified to witness tests at least two weeks prior to tests. Any changes in testing schedules must be communicated immediately to Purchaser.

iii) All defects as a result of testing shall be repaired by GIS Manufacturer at his own expense and shall be documented and corrected prior to shipment. If, in the opinion of Purchaser, a repeat of the faulty test is required after such repairs, this shall also be done at no cost to the Purchaser.

iv) Authorised representatives of Purchaser shall be allowed access to all those areas in GIS Manufacturer's shop where the equipment covered by this contract in produced at all reasonable times for the purpose of inspection and obtaining information on the progress of work.

v) Acceptance by Purchaser's representative of any equipment shall not relieve the GIS Manufacturer from any of his performance guarantees, or from any of his other obligation resulting from this contract.

vi) Following tests are also required to be carried out as routine test free of cost:

a) Routine partial discharge tests shall be performed on all insulators and instrument transformers. The discharge level shall be less than 5 pico Coulombs at this voltage. Purchaser may at his discretion accept alternative tests to prove the integrity of the insulators.

b) Each shipping assembly shall be subjected to a one minute, 50 Hz high voltage withstand test and a partial discharge test. The extinction levels shall be taken as 5 pico Coulombs for switchgear and 3 pico Coulombs for individual insulators.

c) Each enclosure & partition shall be tested to withstand twice rated internal operating pressure and test reports of the tests shall be furnished.

d) Bending strength test and testing of impact strength for insulating rods shall be carried out on one sample in the presence of Purchaser's representative.

e) Tests shall be carried out to verify the gas loss figures guaranteed by the GIS Manufacturer.

f) Mechanical operation test including continuous operating test and timing test.

g) Measurement of the resistance of the main circuit

h) Design and visual checks

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Tests on auxiliary circuits, equipment and interlocks in the control mechanism

9.30.2 Type tests

i) The switchgear and its component circuit breakers, Disconnect Switches, Grounding switches, SF6/oil interface and instrument transformers shall be fully type tested in accordance with the applicable standards mentioned in Data Sheet A2.

ii) Impulse voltage test certificates to prove withstand capabilities against both lightning and switching over voltages should have been conducted on one completely assembled bay which shall include breakers, associated Disconnect Switches, Grounding switches, bus ducts, instrument transformers, etc. These tests shall be carried out after power frequency withstand tests.

iii) The type tests shall be carried out at reputed testing laboratory, the tests must have been carried out during last 5 years. Type test certificates to this effect shall be enclosed with the Bid. If not, the Type tests must be carried out without any time implication to the Purchaser and the price shall be considered in bid.

iv) BIDDER shall carry out the following additional type tests as per relevant IEC standard and furnish test reports to the purchaser:

a) Out of phase making and breaking test on circuit breaker

b) Short line fault test on circuit breaker

c) Electrical endurance test on circuit breaker (applicable for rated voltages).

d) Tests to assess the effects of arcing due to internal faults.

BIDDER shall indicate the cost of each type test as mentioned above in a separate sheet in the price Part.

9.30.3 Site Tests

v) The fully assembled equipment shall be subjected to 1 min. power frequency withstand test at 80% of the rated withstand test voltage and impulse/switching impulse voltage test at site. To test various sections of GIS, it may be necessary for some sections of GIS, to be subjected to more than one such test. All field tests as per relevant IEC standards shall be conducted. The test, the method of applying the test voltage and the requirements for conditioning shall be subjected to agreement between Purchaser and GIS Manufacturer. GIS Manufacturer shall give a detailed programme and description of site testing in the bid and standards followed.

vi) Provision shall be made by GIS Manufacturer for incorporating a test bushing and other necessary testing equipment to facilitate site testing. Test bushing shall be included in GIS Manufacturer's scope, and shall be handed over to Purchaser, if so specified.

vii) The GIS Manufacturer shall indicate the equipment to be made available by the Purchaser for commissioning tests at site. Special tools for erection/testing the GIS shall be supplied by the GIS Manufacturer and indicated in the bid.

viii) The GIS Manufacturer shall also indicate the equipment for diagnostic/online monitoring system for the GIS.

ix) HV testing of the cable plus the plug-in connector in the GIS shall be performed via a suitably designed cable junction box together with a test cable.

9.31 Deputation of Engineers for witness of Tests, Inspection & Training

The Employer's representatives shall be deputed for the following purposes.

Sl. No.	Description	Batch	No of Days	No. of Engineers and Technicians

1	Training at the plant and design office	2	4	3 Engineers 3 Technicians
2	Shop Inspection and Test	As and when required for inspection and test		

The training of employer's personnel shall be as specified in clause 11.0 "Training of Employer's Personnel" of General Technical Specification.

9.32 Employer's Specifications

Sl. No.	Parameters	Unit	Values		
1.0	**System Parameters**				
1.1	Nominal System Voltage	kV	400		
1.2	Highest System Voltage	kV	420		
1.3	No. Of Phases	-	3 Ph		
1.4	Frequency	Hz	50		
1.5	Design Ambient Temperature	o C	50		
1.6	Relative Humidity	-			
1.7	System X/R Ratio	-			
1.8	**Dielectric Strength**				
i)	One Minute Power Frequency Withstand Voltage At Hz.	kV(RMS)	630		
ii)	Rated 1.2/50µS Lightning Impulse Withstand Voltage 132kv (BIL)	kV peak	1425		
iii)	Rated Switching Impulse Withstand Voltage (BSL). For System Voltages 400 kV.	kV peak	1050		
1.9	Short Circuit Current Withstand Current, Duration And System X/R Ratio		kA-RMS (sym)	Seconds	X/R
			63 kA	3 Sec	
1.10	Rated Peak Withstand Current	kA peak	63 kA		
1.11	System Grounding	-	Solid /Effective		
1.12	Co-Efficient of Grounding	-			
1.13	Backup Clearing Time of System	millisecs			
2.0	**Operation & Controls**				
2.2	Closing/Tripping	V DC	220 VDC		
2.3	Drive Motor	Vac/VDC	230 VAC / 220 VDC		
2.4	Alarm Circuits	Vdc	220 VDC		
2.5	Lighting And SpaceHeating	Vac	230 VAC		
3.0	**GIS parameters & GIS Busducts**				
3.1	Installation		Indoor		
3.2	Atmospheric Conditions (For Outdoor Applications)	-	Corrosive		
3.3	Enclosure		Single Phase		
i)	Material		Steel		
ii)	Degree Of Protection		Ip 55		
3.4	Bus Configuration	-	1 Phase		
3.5	Bus Arrangement	-	Double Bus Scheme		
3.6	Material For Bus-Bar	-	Electrolytic COPPER		
3.7	Burn Through Time Of Enclosure For Internal Faults	ms	As Per IEC 62271-203		
3.8	Painting a. Interior b. Exterior	-	RAL 9010 (White) Glossy Finish RAL 7035 (Pebble GREY) Matt Finish,		
3.9	Gas Compartment Requirements	-	GIS Manufacturer To Furnish Drawing Showing The Gas Sections		
3.10	Sf6 Gas Detection System				
i)	Location	-	GIS Manufacturer to Furnish Drawing Showing the Locations for Detectors		

Sl. No.	Parameters	Unit	Values
3.11	Continuous Current Rating @ Design Ambient A) Busbars B) Feeder C) Bus Coupler	 A A A	 **REFER SLD**
3.12	Maximum Temperature Rise For Various Materials And Parts @ Ambient Not Exceeding 40˚c A) Busbars (Conductors & Contacting Part) B) Enclosure & Structure Which Are Accessible To Operator. C) Enclosure & Structure Which Are Inaccessible To Operator	°C °C °C °C	As per IEC 60694. 30 40
3.13	Material of insulators for GIS bus & indoor/outdoor busducts		☐ PORCELAIN ☐ COMPOSITE (Si Resin) ☐ EPOXY (Will be confirmed during DDE)
3.14	GIS busduct length A. Straight lengths B. 90 deg. Bends C. Bellows for interface At indoor-outdoor transit points. (for interconnection of gis with sf6 gas to air bushings for incoming/ outgoing lines) Surge impedance	 m m nos. Ohm	 Vendor to Confirm
3.15	Type of terminations a. GIS to transformer b. GIS to outgoing lines c. GIS to shunt capacitors d. GIS to shunt reactors Surge impedance	 - - - Ohm	 GIS To Transformer GIS To Outgoing Lines – 400 kV Cable / Line. Refer SLD
3.16	Loss Of SF_6 Gas Per Year	%	
3.17	Internal Fault Locator	YES/NO	YES
3.18	GIS Extendable On Both Sides	YES/NO	YES
3.19	Remote Online Gas Monitoring System To Be Provided	YES /NO	YES
3.20	All the components required for enabling future extension like end conductor, gas barrier, end plates, etc considered	YES/NO	YES
3.21	Offline partial discharge monitoring (PDM) system by portable device considered	YES/NO	YES
3.22	Controlled Switching Device Required	YES/NO	YES
4.0	**Circuit Breakers**		
4.1	One minute power frequency withstand voltage at_____Hz.	kV	AS PER IEC STANDARD
4.2	i) Rated Current @ 50 O C ii) Bus Coupler iii) Bus Section iv) Transformer Incomer v) Incoming Lines/Cable Feeders vi) Outgoing Lines/Cable Feeders	 A A A A A	 REFER SLD

Sl. No.	Parameters	Unit	Values
	vii) Shunt Reactor Feeder viii) Shunt Capacitor Feeder	A A	
4.3	Rated Short Circuit Withstand Current for _Seconds	kA	As per IEC standard
4.4	Rated short circuit making current	kA Peak	As per IEC standard
4.5	Percentage dc component	%	As per IEC standard
4.6	X/R ratio		As per IEC standard
4.7	Backup Clearing Time	Milli secs	As per IEC standard
4.8	First Pole To Clear Factor		☐ 1.3 ☐ 1.5
4.9	Rated Maximum Interrupting Time	Cycles	☐ 3 cycles (☐ 60ms ☐ 50ms) ☐ 2 cycles (☐ 40ms ☐ 33ms)
4.10	Rated Cable Charging Breaking Current	A	AS PER IEC STANDARD
4.11	Reactive Breaking Current Capability (If Applicable)	A	AS PER IEC STANDARD
4.12	Rated Single Capacitor Bank Breaking Current Capability (If Applicable)	A	
4.13	Rated Back To Back Capacitor Bank Breaking Current Capability (If Applicable)	A	
4.14	Rated Capacitor Bank Inrush Current Capability (If Applicable)	kA peak	
4.15	Out-Of-Phase Breaking Current	A	As per IEC
4.16	Rated Small Inductive Current Breaking	A	As per IEC
4.17	Line Charging Breaking Current	A	As per IEC
4.18	Number Of Breaks Per Pole		☐ **TWO**
4.19	Auxiliary Contacts i) **Direct Driven** ii) **Multiplied** iii) **Spare**	No.s No.s No.s	10 No s each
4.20	Operating Duty		O-0.3S-CO-3MIN-CO
4.21	Auto Re-Closing (1 Pole/ 3 Pole) Required		Yes 1 Pole
4.22	Voltage Range Of Motor	VAC/VDC	230 VAC / 220 VDC
4.23	Close Coil & Trip Coil Current	A	Vendor to confirm
4.24	Type Designation Of Operating Mechanism		Vendor to confirm
4.25	Degree Of Protection Of Operating Mechanism		Vendor to confirm
4.26	Class Of Breaker		
4.27	Control Switching Device To Be Provided		Yes/No- If Yes Which Breaker -
5.0	**Disconnect Switches And Grounding Switches**		
5.1	Type & Designation Number		
5.2	Rated BIL	kV peak	420/ 680/1050
5.3	Rated Normal Current i) **Transformer** ii) **Bus Section** iii) **Bus Coupler**	 A A A A A	Refer SLD

Sl. No.	Parameters	Unit	Values
	iv) **Feeders** v) **Line/Cable**		
5.4	Rated One Minute Power Frequency Withstand Voltage	kV RMS	680
5.5	Switching Impulse Withstand Voltage (Where Applicable)	kV PEAK	1050
5.6	Rated Withstand Voltages Across The Isolating Distance	kV	AS PER IEC STANDARD
5.7	Voltage Rating Of Motor	VAC/VDC	230 VAC / 220 VDC
5.8	Rated Bus Transfer Switching Current (Double Bus Schemes Only)	A	VENDOR TO CONFIRM
5.9	Short Circuit Making Current For Motorized Ground Switches	kA PEAK.	AS PER IEC STANDARD
5.10	Auxiliary Contacts i) **Direct Driven** ii) **Multiplied** iii) **Spare**	NOS.	10 NO S EACH
6.1	Type	-	Refer SLD
6.2	Voltage Ratio	V	400kv/ Rt3 / 110 / Rt3
6.3	Extended Tap (If Required)	V	
6.4	Burden	VA	Refer SLD
6.6	Secondary Fuse/MCB Rating		MCB
6.7	Parameters As Per Single Line Diagram		YES
6.8	Insulation Type & Class		As per Standard
7.0	**Current Transformers**		
7.1	Type		
7.2	Winding Insulation Type & Class		As per Standard
7.3	CT Ratio		Refer SLD
7.4	Class Of Accuracy		0.2, PX
7.5	Burden	VA	Refer SLD
7.6	Rated Short Time Witstand Current i) **Thermal** ii) **Dynamic**	kA $_{RMS}$ kA $_{peak}$	
7.7	Continuous Thermal Current Rating Factor	%	120%
7.8	Parameters As Per Single Line Diagram		YES/NO
8.0	GIS Surge Arrester		400 KV System
8.1	Required	Yes / No	YES
8.2	Type		Vendor to confirm
8.3	Rrester Voltage	kV	360
8.4	Rated Continuous Operating Voltage	kV	303
8.5	Nominal Discharge Current (8/ 20 µsec Impulse)	kA	20
8.6	Maximum Residual Voltage At Nominal Discharge Current	kV Peak	Vendor to confirm
8.7	Line Discharge Class	kJ/ kV	3
8.8	Two Impulse Energy Capability	kJ / kV	Vendor to confirm

Sl. No.	Parameters	Unit	Values
9.0	**SF6/ Air Bushing**		
9.1	Rated Continuouscurrent	A	Refer SLD
9.2	Mechanical Strength	kN	
9.3	Minimum Phase To Phase Spacing Of Bushings	mm	As per Standard
9.4	Minimum Creepage Distance	mm	25 mm/kV
9.5	Provision Of Structural Support		REQUIRED
9.6	Minimum Bare Conductor Height Above Ground	mm	
9.7	Surge Impedance	ohm	
9.8	SF6-TO-OIL Termination-data requirement including bellow data		
9.9	Cable termination –data requirements along with Surge Impedance		
9.10	Cable sealing end		Outdoor
10.0	Partial Discharge Monitoring System		REQUIRED
10.1	P.D. Monitoring		ON LINE
10.2	Type	HFCT OR UHF	
10.3	Sensors	Nos	
10.4	On Line Monitoring Panel	Type	Microprocessor Based
10.5	Hand Held Monitor		☐ Required
10.	Data Storage Capacity	MB	
10.7	Resolution Time	Millisecs	
11.0	Local Control Panels		
11.1	Quantity	No.	Vendor to confirm
11.2	Type Of Mechanism		Vendor to confirm
11.3	No. of Mechanism Units For Feeder System		Vendor to confirm
11.4	Requirements		
i)	Operation	-	YES
ii)	Alarms	-	YES
iii)	SCADA Interface	-	YES
11.5	Enclosure	-	Steel
11.6	Control Schemes/Block Logic Diagram	-	See Attached Dwg.
11.7	Alarm/Annunciator System	-	See Attached Points List
11.8	Mimic Required	YES / NO	YES
13.0	**Test Requirements For Main Components**		
13.1	Circuit Breakers	Set	2 No.
13.2	Disconnect Switches	Set	2 No.
13.3	Grounding Switch	Set	2 No.
13.4	Current Transformers	Set	2 No.
13.5	Potential Transformers	Set	2 No.
13.6	GIS Surge Arresters	Set	2 No.
13.7	Motor Drive Units	Set	2 No.
13.8	Relays	Set	2 No.
13.9	Main Circuit Resistance	Set	2 No.
13.10	Insulation Resistance Measurement For Main And Control Circuit	Set	2 No.
13.11	SF6 Gas Quality	Set	2 No.
i)	Density		
ii)	Moisture		
13.12	High Voltage Test	Set	2 No.

Sl. No.	Parameters	Unit	Values
14.0	GIS Maintenance Equipment		
14.1	Gas Storage Quantity		
i)	No. Of Cylinders	Nos.	2 No.
ii)	Gas Piping	M	2 No.
14.2	Gas Filling Plant		
i)	Vacuum Pump	Set	2 No.
ii)	Nozzles, Hoses	No.s	2 No.
	Compressors With Gauges, Valves, Filters, Driers & Controls With Necessary Spares	Nos	2 No.
14.3	Portable SF6 Gas Leak Detector	Set	2 No.
14.4	Hygrometer	No	2 No.
14.5	Vacuum Meter	No	2 No.
14.6	Portable Dust Counter	No	2 No.
14.7	Tool For Lamp In Local Panel	No	2 No.
14.8	Special Gas Mask For GIS Maintenance	No	2 No.
14.9	Time Recorders For		2 No.
i)	Breakers	Set	
ii)	Isolators	Set	
14.10	Instrument For Automatic And Continuous Gas Monitoring In Switchgear Room	Set	Yes
15.0	Test Bushing And Other Necessary Testing Equipment To Facilitate Site Testing.		Yes
16.0	Mobile Gas Treatment Plant To Be Included		Yes

9.33 Applicable Standards

Sl. No.	Description	Standards
1	International electro-technical vocabulary	IEC 60050
2	High voltage alternating current circuit breakers	IEC 62271-100
3	Gas-insulated metal-enclosed switchgear for rated voltages 52 kV & above	IEC 62271-203
4	High voltage test techniques	IEC 60060
5	Recommendation for heat treated aluminium alloy busbar material of the aluminium-magnesium-silicon type	IEC 60114
6	Alternating current disconnect switches and grounding switches	IEC 62271-102
7	Bushing for alternating voltages above 1000 volts	IEC 60137
8	Instrument transformers part 1: current transformers	IEC 60044-1
9	Requirements for protective current transformers for transient performance	IEC 60044-6
10	Instrument transformers part 2: inductive voltage transformers	IEC 60044-2
11	Electrical relays	IEC 60255
12	Low voltage fuses	IEC 60269
13	Low voltage motor starters	IEC 60292
14	Specification and acceptance of new sulphur hexafloride.	IEC 60376
16	Synthetic testing of high voltage alternating current circuit breakers	IEC 60427
17	Guide for checking SF-6 gas taken from electrical equipment	IEC 60480
18	Artificial pollution test on HV insulators to be used on ac system	IEC 60507
19	Direct connections between power transformers and gas insulated metal-enclosed switchgear for rated voltages 72.5kV and above	IEC 61639
20	Classification of degree of protection provided by enclosures	IEC 60529
21	Common clauses for HV switchgear and controlgear standards	IEC 60694
22	Additional Requirement For Enclosed Switchgear And Control Gear From 1 kV to 72.5 kV for use in Severe Climate Conditions	IEC 60932
23	Guide for selection of insulators in respect of polluted conditions	IEC 60815
24	Gas Insulated Metal – Enclosed Switchgear For Rated Voltages 72.5 k kV and above – requirements for switching of bus charging circuit by disconnect switches	IEC 61259
25	Specification for transportable gas containers. Seamless steel containers.	BS 5045-1
26	IEEE guide for safety in AC substation grounding	IEEE STD 80
27	Standard for gas insulated substations	ANSI/IEEE C37.122
28	Quality systems – model for quality assurance in final inspection and test	ISO 9003
29	European standard – cast aluminium alloy enclosures for gas filled high voltage switchgear and control gear	EN 50052
30	Wrought aluminium and aluminium alloy enclosure for gas filled high voltage switchgear and control gear	EN-50064
31	Welded composite enclosures of cast and wrought aluminium alloys for gas filled high voltage switchgear and control gear	EN 50069
32	Surge arresters-part4: metal-oxide surge arresters without gaps for AC Systems	IEC 60099-4
33	Surge arresters-part5: selection and application recommendations	IEC 60099-5
34	Cable connection for GIS	IEC 62271-209
35	Guide for partial discharge measurements in power switchgear	ANSI/IEEE 1291
36	Code for welding	ASME
37	SF6 to air bushing	IEC 60037

Sl. No.	Description	Standards
38	Paint shade	IS 5
39	Low voltage switchgear and control gear	IEC 60947
40	Boiler and pressure vessel code	ANSI/ASME
41	Immunity standard on electrostatic discharge	IC61000

9.34 Mandatory Spares

Sl. No.	Description	Unit	Qty.
1	**General Spares**		
1.1	Cable Connection Enclosure with the main Circuit (if applicable)	No. of each type	1
1.2	SF6 gas Pressure Relief Devices of each type along with O-rings	Sets of each type	2
1.3	SF6 Pressure gauge cum switch OR Density monitors and pressure switch, as applicable, of each type	5% of total population (max 5 nos. and min. 1 no.)	
1.4	Coupling device of each type for pressure gauge cum switch for connecting Gas handling plant	Sets of each type	2
1.5	Rubber Gaskets, "O" Rings and Seals for SF6 gas of each type	Sets of each type	3
1.6	Molecular filter for SF6 gas with filter bags	of total weight	5
1.7	All types of Control Valves for SF6 gas of each type	Nos. of each type	3
1.8	SF6 gas	20% of total gas quantity	
1.9	Locking device to keep the Dis-connectors (Isolators) and Earthing switches in close or open position in case of removal of the driving Mechanism	Nos. of each type	3
1.10	Spare EHV Cable of longest phase of a feeder as applicable (if applicable)	1	1 Run
1.11	Spares for local control cabinet including MCB, Fuses, Timers, Aux. relays, Contactor, Push Buttons, Switches, Lamps, Annunciation Windows etc. of each type & rating and terminal of each type	Sets of each type	2
1.12	HV Cable Termination kit of each type (if applicable)	Sets of each type	2
1.13	HV Cable Jointing kit of each type (if applicable)	No. of each type	1
1.14	UHF PD Sensors of each type	5% of total population (max 5 Nos. and min. 1 No.)	
1.15	Support Insulator/Gas Barrier of each type along with associated contacts and shields	Nos. of each type	5
1.16	SF6 to air bushing of each type & rating along with conductor and enclosure	No. of each type	1
1.17	SF_6 Gas Filling Kit(Hose, valve adaptors, regulator)	Complete Set	1
1.18	Gas Density Monitor for Each compartment	Set	1
1.19	Gas Sampling Port Adapter and Gas Filters (Moisture/Particle)	Set	1

Sl. No.	Description	Unit	Qty.
1.20	Partial Discharge Sensors (UHF/VHF) -Online condition monitoring	Set	1
1.21	Local Monitoring Display Unit -HMI panel for GIS	Set	1
1.22	GIS Alignment Tool Kit-OEM-specific torque tools, alignment jigs	Full kit	1
2	**SF6 Circuit Breaker**		
2.1	Complete Circuit Breaker (1 phase unit) of each type & rating complete with interrupter, main circuit, enclosure and Marshalling Box with operating mechanism to enable replacement of any type/rating of CB by spare (as applicable)	Sets of each type	1
2.2	Trip coil assembly with resistor as applicable,	Sets of each type	2
2.3	Closing coil assembly with resistor as applicable,	Sets of each type	2
2.4	Grading Capacitor	Nos.	3
2.5	Rubber gaskets, 'o' rings and seals	Set of each type	1
2.6	Molecular filter	Nos.	2
2.7	Density/Pressure monitoring systems	No.	1
2.8	SF6 Gas	15% of total used quantity in substation	
2.9	Relays, Power contactors, push buttons, timers & MCBs etc. of each type and rating	Sets of each type	1
2.10	Auxiliary switch assembly,	Sets of each type	2
2.11	Operation Counter	Sets of each type	2
2.12	Window scope/ Observing window,	Sets of each type	2
2.13	LOTO arrangement provision	Set of each type	1
2.14	Hydraulic operating mechanism with drive motor of each type	Sets of each type	1
2.15	Ferrules, joints and couplings of each type	Sets of each type	1
2.16	Hydraulic filter of each type	Sets of each type	1
2.17	Hose pipe of each type	Sets of each type	1

Sl. No.	Description	Unit	Qty.
2.18	N2 Accumulator of each type	Sets of each type	1
2.19	Valves of each type including Safety valve if	Sets of each type	1
2.20	Valves of each type	Sets of each type	1
2.21	Pipe length (copper & steel) of each size & type	Sets of each type	1
2.22	Pressure switches of each type	Sets of each type	1
2.23	Pressure gauge with coupling device of each type	Sets of each type	1
2.24	Hydraulic oil	20% of total qty. used	
2.25	Pressure Relief Device of each type	Set of each type	1
2.26	Spring Charging Motor with Limit switch	Nos. of each type	2
2.27	Complete Spring Operating Mechanism including charging mechanism etc. of each type	Sets of each type	1
2.28	Spring Charging Motor	Nos. of each type	2
3	**Isolators**		
3.1	Complete set of 3 nos. of single phase / one 3-phase isolator of each type, dimension, current & voltage rating including main circuit, enclosure, driving mechanism and support Insulator etc. to enable replacement of any type/rating of Isolator by spare	Set of each type	1
3.2	3 No. of single phase / one no of 3-phase Maintenance Earthing switch of each type, dimension, current & voltage including main circuit, enclosure, driving mechanism and support Insulator etc. to enable replacement of any type/rating of Earth Switch by spare	Set of each type	1
3.3	3 No. of single phase / one no of 3-phase Fast Earthing switch of each type, dimension, current & voltage rating including main circuit, enclosure, driving mechanism and support Insulator etc. to enable replacement of any type/rating of Earth Switch by spare (if applicable)	Set of each type	1
3.4	Copper contact fingers for isolator male & female contact along with corona shield– for one complete (3 phase) isolator of each type and rating	Set of each type	1

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Sl. No.	Description	Unit	Qty.
3.5	Copper contact fingers for Maintenance Earthing switch male & female contacts along with corona shield, for one complete (3 phase) earthing switch of each type and rating	Set of each type	1
3.6	Isolator Arms with finger contacts and current carrying assembly	Set	1
3.7	Copper contact fingers for Fast Earthing switch male & female contacts along with corona shield, for one complete (3 phase) earthing switch of each type and rating (if applicable)	Set of each type	1
3.8	Open / Close contactor assembly, timers, key interlock, interlocking coils, relays, push buttons, indicating lamps Power contactors, resistors, fuses, MCBs & drive control cards etc. for one complete MOM box (3 – phase gang operated or 1 – phase unit) dis-connector and (3 phase) earthing switch of each type and rating		
3.9	For Isolator	Set of each type	1
3.10	For Maintenance Earth switch	Set of each type	1
3.11	For Fast Earthing Switch (if applicable)	Set of each type	1
3.12	Limit switch and Aux. Switches for complete 3 phase equipment		
3.13	For Isolator	Sets of each type	2
3.14	For Maintenance Earth switch	Sets of each type	2
3.15	For Fast Earthing Switch (if applicable)	Sets of each type	2
3.16	Drive Mechanism of each type		
3.17	For Isolator	No. of each type	1
3.18	For Maintenance Earth switch	No. of each type	1
3.19	For Fast Earthing Switch (if applicable)	No. of each type	1
3.20	Motor for Drive Mechanism of each type		
3.21	For Isolator	Nos. of each type	3
3.22	For Maintenance Earth switch	Nos. of each type	3

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Sl. No.	Description	Unit	Qty.
3.23	For Fast Earthing Switch (if applicable)	Nos. of each type	3
3.24	Mechanical Interlock Devices interlock for earth switch and isolator	Set each type	1
3.25	LOTO arrangement provision	Set each type	1
4	**Current Transformer**		
	Complete CT with Terminal connector & structure of each type and rating with enclosure to enable replacement of any type/rating of CT by spare	No. of each type	1
4.2	Primary Terminal Bushing	Sets	2
5	**Voltage Transformer**		
5.1	Complete VT with Terminal connector & structure of each type and rating with enclosure to enable replacement of any type/rating of VT by spare (if applicable)	No. of each type	1
6	**Surge Arrestor**		
6.1	Gas insulated SA for of each type and ratings enclosure & surge monitor counter to enable replacement of any type/rating of Gas Insulated SA by spare (if applicable)	No. of each type	1
6.2	Surge counter/ monitor of each rating and type	No. of each type	1
6.3	**Oil to SF6 bushing** for Transformer/Reactor as applicable of each rating	No. of each type	1
6.4	Oil to Cable Termination kit for Transformer as applicable of each rating	Nos. of each type	2
6.5	Controlled Switching Device along with Transducers, Sensors, Contactors, Switches etc.	Set of each type	1

CHAPTER-10: 420 kV AND 145kV XLPE CABLES

10.1 Scope of Work

This Specification covers the requirements of sizing, design, engineering, material selection, constructional features, manufacture, inspection and testing at the VENDOR'S or his SUB-VENDOR'S Works, delivery to Site including transit insurance, installation, testing & commissioning, training of employer's personals and performance testing and of 420 kV and 145 kV XLPE cables for connecting from GIS to Pothead yard.

Single core 420 kV high voltage XLPE cables will be installed and connected from the GIS to the outside pothead through the cable tunnel for power evacuation between the main step- up transformers and the 420kV GIS switchyard and between the Interconnecting transformers HV terminal and the 420kV GIS switchyard.

Single core 145 kV high voltage XLPE cables will be installed and connected from the Interconnecting transformer LV terminal to the outdoor 132kV GIS / outdoor.

400kV and 132kV XLPE cable details.

Sl. No.	System Voltage U (kV)	Rated Voltage U_0 / U (kV)	Highest System Voltage U_m (kV)
1.	132	76/132	145
2.	400	220/400	420

The cables shall be suitable for maximum conductor operating temperature of 90°C during normal working and 250°C at the end of a short circuit operation where combination of ambient temperature and temperature rise due to load results in Conductor temperature not exceeding 90°C and 250°C under short circuit conditions. Emergency overloading of the cables and its temperature rise with respect to the time duration shall be considered as per project requirement.

10.2 Codes and standards

i) The design, manufacture and performance of cables shall comply with all currently applicable statutes, regulations, and safety codes in the locality where the equipment will be installed. The codes and standards mentioned in this specification shall be latest as on the day of execution of the works unless otherwise specified. The revisions in the relevant codes and standards if any after the date of award of contract shall be informed by the Vendor/Contractor to the Consultant/ Owner within 30 days of the issue of such revision of the code/ standard. Consultant/ Owner may approve use of the earlier code/ standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed. Nothing in this specification shall be construed to relieve the VENDOR of this responsibility.

ii) In case of conflict between the applicable standards and this specification, the more stringent of the two shall govern.

10.3 Materials and Construction

i) The materials and the construction of the cables shall conform to the requirements specified in IS/IEC. The cables may conform to any other standards which are equal or better than the standards mentioned in Data Sheet A2. The Bidder shall indicate the deviations (if any) from the preferred IS/ IEC codes that affect the rating and performance.

ii) EHV cables shall have following constructional features as specified in Data Sheet A1:

a) Conductor – The conductor shall consist of annealed plain copper wires, well compacted, stranded/segmented/Milliken. The conductor shall have a smooth surface finish. The conductor shall be clean and free from foreign particles which

may create high stress points due to contamination. The grade and quality of material used shall be as per IEC/IS.

b) Conductor shield/screen – The conductor screen shall consist of a semi conducting compound layer and shall be provided over the conductor by extrusion. The outer surface of the conductor screen shall be circular and free from protrusions. The outer surface of the conductor screen shall be firmly and continuously bonded to the inner surface of the insulation.

c) Insulation – The conductor insulation shall comprise of a super clean grade layer of cross-linked polyethylene (XLPE). The insulation shall be applied by extrusion over the conductor screen using dry curing process to form a homogeneous body free from contaminants, voids, protrusion and moisture content.

d) Insulation shield/screen – The insulation screen shall comprise of a semi-conducting compound similar to conductor screen (clause 3.2b). It shall be applied directly over the insulation core by extrusion. The inner surface of the insulation screen shall be smooth and free of protrusions and irregularities. It shall be firmly and continuously bonded to the outer surface of the insulation.

e) Metal wire Screen/ Shield - The metallic sheath of corrugated Copper sheath shall be provided over the non- metallic part of the insulation screening as specified in Data Sheet A.

f) Synthetic Water blocking layer above metal wire shield - The water blocking layer shall consist of a synthetic semi-conducting moisture swellable layer covering the entire surface area of the metal screen/shield. It may be provided above conductor, insulation screen, metal screen and armour as per project specific requirement or local state EB requirement as specified in Data Sheet A.

g) Armouring – Armouring shall be provided for Copper wire and polyal combination if specified in Data Sheet A.

h) Outer sheath - The outer sheath shall consist of an extruded layer of black, PE ST-7 or PVC ST 2 or TM 53 as specified in Data Sheet A. The outer sheath shall be of sufficient hardness to discourage rodent or

(i) Outer conductive coating / layer - The outer conductive layer shall consist of a Graphite coating / an extruded semi- conducting layer over the outer sheath.

iii) XLPE cable shall be designed to withstand the thermal and electro mechanical stresses under the transient, steady state and fault conditions.

iv) The sheath/screen bonding system shall provide a continuous current path through the cable sheath & jointing kits and shall be bonded. The bonding ends shall be suitably earthed with/without SVL as per the approved configuration.

v) The sheath voltage under full load conditions shall not exceed the voltage specified / allowed in relevant standards for safety of personnel as well as satisfactory working of cable. Bidder shall give along with the bid, details of configuration proposed with calculations so as to limit induced voltage of sheath within specified limits.

vi) EHV Cables shall be fire retardant low smoke low halogen type. Directly buried cables shall be essentially armoured type.

vii) Cables shall be derated for the site ambient and ground temperatures, grouping and soil resistivity as per relevant Indian Standards.

10.4 Manufacturing Process and Quality

i) The conductor screen, insulation and insulation screen shall be extruded in one simultaneous triple extrusion process through common crosshead. The process shall be designed to eliminate hot spots and ensure smoothness of the screen surfaces.

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ii) The cross linking and curing shall be a dry curing process under high pressure to eliminate the formation of voids in the insulation.

iii) The entire manufacturing process shall be such as to eliminate irregularities like protrusions, voids and contamination etc.

iv) Raw materials used for manufacture of cable shall be of highest quality and all incoming raw material should be checked / tested to ensure that it meets manufacturer's material specification.

v) Expert supervision shall be provided at each stage of manufacturing. Complete details of manufacturing process along with details of automatic manufacturing plant, shall be furnished by Bidder along with the bid.

10.5 Tests

i) Cables shall be subjected to type, routine, acceptance and special tests in accordance with standards mentioned in IS/IEC and specific requirements of the project and Data Sheet A1 and as mentioned below:

a) Type Tests

Tests required to be conducted by the Manufacturer before supply of a cable on a general commercial basis in order to demonstrate satisfactory performance characteristics to meet the intended specification. Purchaser at his option may accept previous type test reports or insist on conducting fresh type tests on the cables ordered.

b) Routine Tests

Tests required to be conducted compulsorily by the Manufacturer on all finished cables to demonstrate integrity of the cable.

c) Acceptance Tests

Tests required to be carried out by the Manufacturer at the option of the Purchaser on samples taken from a lot for the purpose of acceptance of the lot.

d) Special Tests

Special tests required to be carried out by the Manufacturer as per the agreement with Purchaser. These will be in addition to type, routine and acceptance tests.

10.6 Method of tests

Type, routine, acceptance and special tests shall be conducted on cables as per Indian Standards / IEC standards or tender specification, as applicable. For the method of tests relevant IS / IEC shall be referred. Wherever the method or test parameters are modified in the tender specification, such methods or parameters shall be considered for testing of cables.

10.7 Identification Packing and Marking

10.7.1 Manufacturer's identification

The Manufacturer shall be identified throughout the length of the cable by Manufacturer's name or trademark, embossed on the outer sheath of cable. Voltage grades, cable size & code and the year of manufacture shall also be embossed on the outer sheath as per IS.

10.7.2 Cable Code - Following code shall be used for designating the cable:

Constituent	Code Letter
Aluminium conductor	A

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Copper conductor	C
XLPE Insulation	2X
Metal Screen	Ts
Metal sheath/Moisture Barrier	Tx
Nonmagnetic round wire armour/string	Wa
PVC outer sheath	Y
PE Outer Sheath	PE
Conductive coating/Conductive layer	CC

10.7.3 Packing and marking

i) Cables shall be wound on a drum conforming to specification as per IS indicated in Data Sheet A2. The ends of the cables shall be sealed by means of non-hygroscopic sealing caps. Necessary cable pulling eye shall be integrated with the sealing at the cable unwinding end. Steel drums shall be employed for winding the cables when specified in Data Sheet A 1 / Section C.

ii) The following information shall be indelibly marked on the cable drum:

a) Reference to applicable standard

b) Manufacturer's name and trademark

c) Type of cable and voltage grade

d) Nominal cross-sectional area of conductor

e) Cable Code

f) Length of cable in drum

g) Reel Number

h) Gross / Net weight

i) Direction of rotation of drum

j) Country of Manufacture

k) Year of manufacture

10.8 Cable Installation

i) The cable Manufacturer shall furnish to the Purchaser, recommendation on jointing, terminations, cross bonding of armour/sheath, laying, requirement of link boxes for earthing and requirement of surge suppressors/sheath voltage limiters considering type of cable, type of laying and route length.

ii) The cable Manufacturer shall also furnish current ratings and rating factors for different ambient and laying conditions.

iii) Electrical test after installation – Tests after installations are made when the installation of the cable and the accessories have been completed.

iv) DC voltage withstand test or Low frequency AC test shall be conducted as specified in data Sheet A1.

10.9 Information to be given by Bidder

i) In addition to information called for in the Data Sheet B enclosed with this Specification, the Bidder shall give the following information with the Bid:

ii) Type test certificates for cables of similar voltage class from any NABL accredited testing laboratory not older than five years on the date of submission of the Bid for the following tests:

a) Bending test

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b) Tan-delta measurement

c) Partial discharge test

d) Heating cycle voltage test

e) Lightning impulse voltage test

f) Power frequency withstand voltage

g) Detailed drawings with dimensions of the cables and all accessories, including –

h) Cross sectional view of cable, indicating the dimensions and material used in each type of construction.

i) Splices and straight joints.

j) Terminations, link boxes and surge suppressors connections.

iii) Descriptive information regarding cable and accessories and test details of installations of similar cables now in service with description, cable performance, outages suffered and cause of outages.

iv) Recommended method for locating cable faults, apparatus required for locating the faults.

v) Whether cable distributed temperature monitoring feature provided either with fiber optic cables integral with the cable or by any other equivalent method.

10.10 Deputation of Engineers for witness of Tests, Inspection & Training

The Employer's representatives shall be deputed for the following purposes.

Sl. No.	Description	Batch	No of Days	No. of Engineers and Technicians
1	Training at the plant and design office	1	3	2 Engineers 2 Technicians
2.	Shop Inspection and Test	As and when required for inspection and test		

The training of employer's personnel shall be as specified in clause 11.0 "Training of Employer's Personnel" of General Technical Specification.

10.11 Erection & Maintenance tools & Equipment

i) Whether included in the Bidder's recommendations or not, unit prices for the following items shall be quoted together with their suggested quantities and catalogue numbers. The Purchaser reserves the right to select any or all the items offered.

ii) Capacitance Bridge

This shall be suitable for operation on both AC mains and storage batteries. Facilities shall be provided for both audio and visual indications of the balance of the bridge.

iii) Fault Locating Equipment

a) Digital fault locating equipment along with the accessories like surge generator etc.

b) Acoustic detector for locating underground fault by capacitor discharge methods.

iv) Equipment for locating PVC sheath fault.

v) Equipment for measuring the thermal resistivity of soil.

vi) AC and DC test kit.

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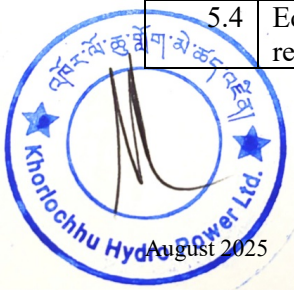
10.12 Employer's Specifications

Sl. No.	Item	Unit	Technical Data	
1	**System Particulars**		**400 kV Power Cable**	**132 kV Power Cable**
1.1	System voltages Uo/U/Um	kV	220/400 (420) kV	76/132 (145) kV
1.2	Voltage grade of cables Uo/U	kV	220/400 kV	76/132 kV
1.3	No. of phases and frequency		3 Phase, 50 Hz	
1.4	System neutral earthing		Effectively earthed	
1.5	System Fault level for which the cable shall withstand (symmetrical short circuit and duration)	kA, Sec	63 kA, 3 Sec	
1.6	Basic impulse level for 400 kV cables	kV (Peak)	1425	
1.7	Maximum allowable temperature for cables and accessories			
i)	At rated full load and at site conditions	°C	90	
ii)	Safe overload capacity at site conditions	%	10%	
iii)	Emergency overloading capacity temperature	°C	130°C for 3 hrs – Yes / No Any other -	
iv)	The conductor temperature after a short circuit for 1 sec shall not exceed (with conductor temperature at start of short circuit as 90 °C)	°C	250	
	Construction Details			
2	**Cable code**		**C2xTsWaYcc**	
2.1	Conductor cross section	Sq.mm.	Vendor to submit the conductor sizing calculation.	
2.2	Conductor			
2.3	Material		Copper	
i)	Shape		Stranded Compact Circular Milliken/ Four segmented electrical conductor	
ii)	Semi conducting tape required		Yes	
iii)	Conductor screen / shield			
2.4	Material		Extruded Semi Conducting XLPE	
i)	Thickness	mm	1 mm	
ii)	Insulation		Cross linked polyethylene (XLPE)	
2.5	Insulation screen / shield			
2.6	Material		Extruded Semiconducting XLPE	
i)	Thickness	mm	0.8 mm	
ii)	Resistivity of semi conducting screen		Shall not exceed 500 Ohm-mtr	
	Synthetic Water Blocking Layer Above Conductor Insulation Shield/Screen			

Sl. No.	Item	Unit	Technical Data
2.7	Required		Yes
i)	Material		Semi conducting Water Blocking tape
ii)	Metal sheath		
2.8	Required		Yes
i)	Material		Copper
ii)	Configuration		Plain / Corrugated
iii)	Fault current withstand capability kA and duration	kA, sec	63 kA, 3 Sec
iv)	Synthetic water blocking layer above metal sheath		
2.9	Required		Yes
i)	Material		Semi conducting Water Blocking tape
ii)	Metal screen / shield		
2.10	Required		Yes
i)	Material		Annealed Copper wire with copper contact tapes
ii)	Fault current withstand capability kA and duration	kA, sec	
iii)	Synthetic water blocking layer above metal screen		
2.11	Required		Yes
i)	Material		Non conducting Water Blocking tape
ii)	Separator sheath		Extruded PVC / Black Polyethylene
2.12	Armour		
2.13	Required		Yes
i)	Material		COPPER
ii)	Type		Round wire/ strips
iii)	Fault current withstand capability kA and duration	kA, sec	
iv)	Outer sheath		
2.14	Material		ST1, ST2 IN PVC ST3, ST7 in Black Polyethylene HDPE , TM 53
i)	Whether FRLS characteristic required		Yes
ii)	Conducting layer over outer sheath		Graphite
2.15	TESTS		
3	Applicable standards		As IS/IEC specified in Data Sheet A2
3.1	TESTS		

Sl. No.	Item	Unit	Technical Data
3.2	Type testsWhether previous test reports will be sufficientWhether samples to be type tested against this order		Yes Yes
i)	Routine tests		All tests as per specifications & IS / IEC Standards
ii)	Acceptance as per tender specification		Yes
iii)	Special tests DC voltage withstand test Low frequency AC test Any other Any other		Yes Yes
iv)	Whether tests will be witnessed by Purchaser or his representative		Yes/No/ Will be intimated after order
v)	Installation, termination and joints		
4	Ambient temperature	°C	50
4.1	Ground temperature	°C	
4.2	Thermal resistivity of soil		
4.3	Laying configuration		Trefoil / Flat
4.4	Method of laying		Directly in ground/ metaled road/installed outdoor in free air/ laid in underground ducts/trenches
4.5	Depth of burial	mm	
4.6	TERMINATION		
4.7	Type		Indoor/Outdoor/Bushing/Push on/Heat Shrinkable/SF6
i)	ault current withstand capability kA and duration		Same as 1.5 above
ii)	Drum length	mtr	Vendor to Confirm
4.8	Joints required		Yes
4.9	Earth link boxes required		Yes
4.10	Surge suppressor required		Yes
4.11	Type of bonding armour		One end earthed/Both ends earthed/ Cross Bonded
4.12	Sheath voltage limiter required		Yes
4.13	ERECTION / MAINTENANCE TOOLS		
4.14	Capacitance bridge required		Yes
5	Digital fault locating equipment required		Yes
5.1	Acoustic detector for indoor ground fault detection required		Yes
5.2	High pressure testing kit required		Yes
5.3	Equipment for locating PVC sheath fault		Yes
5.4	Equipment for measuring the thermal resistivity of soil		Yes



10.13 Applicable Standards

Sl. No.	Description	Standard
1	Tests for power cables with extruded insulation for rated voltage up to 150 kV	IEC - 60840
2	Tests for power cables with extruded insulation for rated voltage above 150 kV up to 500 kV	IEC- 62067
3	XLPE Cable specification for working voltages from 66 kV up to and including 220 kV	BIS- 7098 (Part-3)
4	Tests procedures and requirements for high voltage cable terminations	IEEE - 48
5	Partial discharge measurements	IEC- 60270
6	Calculation of continuous current carrying capacity	IEC- 60287-1-1
7	Specification for drums for electric cables	IS: 10418

10.14 Mandatory Spares

Sl. No.	Items	Unit	Qty
1	Control cables	5% of total Qty for each type of cable	
2	Signal cables	5% of total Qty for each type of cable	
3	EHV & HV Cable Termination kit of each type (if applicable)	Sets of each type	2
4	EHV & HV Cable Jointing kit of each type (if applicable)	No. of each type	1
5	Lugs of each size	Nos. of each type	100
6	Spare cable laid the full length	2 each for 420 kV and 145kV (The cables has to be laid with all accessories ready to use during emergency)	

CHAPTER-11: POTHEAD YARD

11.1 Scope of Work

This Specification covers the requirements of sizing, design, engineering, material selection, constructional features, manufacture, inspection and testing at the VENDOR'S or his SUB-VENDOR'S Works, delivery to Site including transit insurance, installation, testing & commissioning and performance testing of Pot Head yard equipment's rated as mentioned below for outdoor use on 50 Hz Power systems.

The Pothead yard of the will be outdoor type. The 400 kV cables will be brought to yard through Cable tunnel. The pothead has 02 nos. Line Feeders and 01 no ICT feeder.

11.2 Codes and Standards

i) The design, material, construction, manufacture, inspection, testing and performance of the Pot Head yard equipment's and accessories shall comply with all currently applicable statutes, regulations, and safety codes in the locality where the equipment will be installed. Nothing in this specification shall be construed to relieve the VENDOR of this responsibility.

ii) The codes and standards mentioned in the various specifications and requirements specified in the enquiry document shall be latest as on the day of award of contract of the works unless otherwise specified. Contractor shall be responsible to inform to the Consultant/ Owner in case of any revisions/re-affirm/amendment in the relevant codes and standards after the date of award of contract within 30 days of the issue of such revision/re-affirm/amendment of the code/ standard. Consultant/ Owner may approve use of the earlier code/ standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed.

iii) The applicable Codes and standards shall be considered. However, for some special applications the Pot Head yard may have to conform to some higher requirements, which will be specified in the specification. In such specific cases, this specification shall take precedence over the standard requirements indicated in the applicable Industry Standards.

11.3 Components of Pot head yard Assembly

The components of Pot Head yard assembly having compact and modular design shall essentially consist of following items and their accessories specified in subsequent clauses:

i) ICT Transformer

ii) Lightning Arresters

iii) Bus Post insulators & Disc Insulators

iv) Capacitor Voltage transformers

v) Current Transformer.

vi) Isolator Motor operated with motor operated Earth Switch.

vii) SF6 Gas-Insulated- to - Air Bushings.

viii) Gantry Tower Structures & Equipment Support Structures.

ix) ACSR Conductors.

x) Terminal connectors and Clamps.

11.4 Lightning arresters

11.4.1 Design Features

i) The characteristic data of gapless metal-oxide surge arresters shall be selected based on guidelines of applicable standard. The parameters such as rated voltage, continuous operating voltage, nominal discharge current, residual voltages, line discharge class, pressure relief class and pollution withstand characteristics shall be considered as per site condition & SLD.

ii) The minimum criteria for requirements and testing of gapless metal oxide surge arresters shall be as per guidelines of applicable standard.

iii) The Lightning arresters shall be capable of discharging over-voltages occurring during switching of unloaded transformers, reactors and long lines.

11.4.2 Constructional features

i) Lightning arresters shall be of the hermetically sealed type and of self-supporting construction. They shall be suitable for mounting on the PURCHASER's concrete or steel structures. They shall be provided with pressure relief devices and shall be capable of withstanding the internal pressures developed during various discharges or should safely vent the internal pressures associated with arrester failure without violent shattering of LA housing. Arrester with polymer insulator shall be with sufficient cantilever strength and withstand the maximum wind force.

ii) All metal parts shall be of non-rusting and non-corroding metal. Bolts, screws and pins shall be provided with lock washers, keys or equivalent locking facilities.

iii) The Lightning Arrester shall not fail due to polymer contamination.

iv) Seals shall be effectively maintained even when Lightning Arrester discharges rated current.

v) The end fittings shall be of non-magnetic material

vi) The outer insulator housing shall be so coordinated that external flashover will not occur due to application of any impulse or switching surge voltage up to the maximum design value for arrester.

vii) Polymer housed surge arrester shall be hydrophobic and non-explosive type with zero short circuit failure.

11.4.3 Accessories

11.4.3.1 Discharge Counter

i) Self-contained discharge counter suitably enclosed for outdoor use and requiring no auxiliary or battery supply shall be provided for each single pole unit as required. The discharge counter shall be visible through an inspection window. The counter terminals shall be so located that incoming and outgoing connections are easily made with minimum possible bends. Suitably sized bypass shunts of copper to facilitate bypassing the discharge counter shall be furnished. The terminal connectors shall permit the connection of these shunts. Discharge counter shall be provided with potential free contacts for remote SCADA indication.

ii) The connection between lightning arrester earth terminal and discharge counter terminal shall be XLPE insulated for a minimum of 3.6 kV and this insulated conductor shall be supplied along with the arrester.

iii) A leakage current meter / monitor as an integral part of the discharge counter shall be supplied as required. The counter and the meter shall be so arranged that it is possible to read the leakage current values from ground level. The value of leakage current beyond which the operation is abnormal shall be clearly marked in red colour on the meter.

11.4.3.2 Grading

Grading resistors and/or grading capacitors and grading rings shall be provided for uniform voltage distribution between the units making up the arrester, as dictated by the voltage class of the arrester.

11.4.3.3 Name Plate

Each lightning arrester shall be provided with non-rusting and non-corroding name plate bearing identification as per the applicable standards.

11.5 Instrument Transformers

11.5.1 Capacitive voltage transformer

i) The instrument transformers i.e., Current and Voltage transformers shall be single phase transformer units and shall be supplied with a common marshalling box for a set of three single phase units.

ii) CVTs shall be oil filled hermetically sealed type

iii) In case of SF6 filled CTs/EMVTs, it shall be provided with a suitable SF6 gas density monitoring device, with NO/NC contacts to facilitate remote annunciation and tripping in case of SF6 leakage. Provisions shall be made for online gas filling. Suitable rupture disc shall be provided to prevent explosion.

iv) The CTs, CVTs and EMVTs shall be given tropicalised treatment for satisfactory operation in hot and humid climate.

v) The Capacitive voltage transformers (CVT) shall be thermally and dielectrically safe when the secondary terminals are loaded with guaranteed thermal burdens.

vi) The damping device shall be permanently connected to one of the secondary winding and shall be capable of suppressing ferro-resonance oscillations.

vii) CVTs shall be suitable for high frequency (HF) coupling for power line carrier communication. Carrier signals must be prevented from flowing in to potential transformer (EMU) metering circuit by means of RF choke/reactor suitable for effective blocking of the carrier signals over the entire frequency range of 40kHz to 500kHz. HF terminal shall be brought out through a suitable bushing and shall be easily accessible for connection to the coupling filters of the carrier communication equipment. The HF terminal shall be provided with earthing link with fastener.

viii) Capacitance value of CVT shall be suitable for PLCC frequency range and it shall be subjected to approval by respective approving authorities.

ix) The end of the primary winding intended to be earthed shall be brought out through a bushing and earthing connection shall be made outside by means of disconnecting link. This is required to facilitate meggering of the primary winding for which the earth connection has to be removed. The neutral side bushings of the voltage transformers shall be rated for 1.1kV class.

x) A protective surge arrester/spark gap shall preferably be provided to prevent breakdown of insulation by incoming surges and to limit abnormal rise of terminal voltage of shunt capacitor, tuning reactor, RF choke, etc. due to short circuit in transformer secondary. The details of this arrangement (or alternative arrangement) shall be furnished by Bidder for Owner's review.

xi) The protection cores shall not saturate at about 1.5 times the rated voltage for a min. duration of 30 secs.

xii) The CVT secondary shall include necessary MCBs with auxiliary contacts for alarm for protecting the secondary winding. All the terminal boxes shall be hot dip galvanized with IP-55 degree of protection.

xiii) CVT assembly shall be suitably braced to withstand stresses induced due to seismic disturbances. The tank/base and all exposed ferrous parts shall be hot dip galvanized conforming to applicable standards

xiv) No turns compensation will be used in case of class 'PS' CTs. Turns compensation, if any, should be clearly brought out in the offer.

xv) Oil filled insulator / bushings shall be hermetically sealed to prevent ingress of moisture. A cushion of nitrogen gas may be provided to allow for expansion. Care should be taken in design to ensure no nitrogen leakage.

xvi) Neutral of all cores of CTs, CVTs and EMVTs shall be formed in marshalling box of the respective equipment. Cables with sufficient number of cores shall run from these marshalling boxes to protection panels. The neutral of CTs, CVTs, and EMVTs shall be earthed only at protection panels by means of a disconnecting link.

xvii) For CTs, EMVTs and CVTs, shock indicators shall be provided for recording shock/vibration during transport.

xviii) The CTs, EMVTs & CVTs shall be suitable for hot line washing.

xix) Name plate shall conform to the requirements of IEC/IS incorporating the year of manufacture. The rated current, extended current rating in case of current transformers and rated voltage, voltage factor in case of voltage Transformers shall be clearly indicated on the name plate. The rated thermal current in case of CT shall also be marked on the name plate.

xx) The intermediate voltage in case of capacitor voltage transformer shall be indicated on the name plate.

xxi) The instrument transformers shall be provided with the following accessories:

a) Two earthing terminals on tanks on opposite sides for connecting the earthing conductors.

b) Oil level gauge/Oil sight glass

c) Filling and draining plugs

d) Power factor testing terminal

e) Facility for lifting bushings and tanks

f) Insulating oil required for first filing plus 10% as spare. Dielectric Dissipation Factor (tan d) of the transformer oil shall be < 0.005.

g) The number of secondary cores, accuracy class and burden shall be in accordance with the requirements of the protection and metering system.

h) The rated burden of Voltage Transformer cores shall be closer to the maximum burden requirement of metering and protection system for better sensitivity and accuracy and it shall not exceed 30VA.

i) The accuracy class for metering core shall be equal to or better than the accuracy class of the meter specified in the Central Electricity Authority (Installation and Operation of Meters) Regulations, 2006.

j) Wherever Power Line Carrier Communication is provided, Capacitor Voltage Transformer complying with relevant standards shall be used as the same are suitable for carrier coupling and the capacitance of Capacitor Voltage Transformer shall be decided depending on Power Line Carrier Communication requirements.

k) In case of digital substations, Non-Conventional Voltage Transformers or conventional Voltage Transformers with merging units that are interfaced with the process bus and station bus architecture shall be used.

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11.5.2 Current Transformers

i) The CTs shall have single primary of either ring type or hairpin type or bar type. In case of low ratio CTs, multi-turn primary windings may be used.

ii) The secondary windings shall be totally encased in metallic shielding providing a uniform equipotential surface for even electric field distribution.

iii) The upper part of insulation assembly sealing on primary bar shall be properly secured to avoid any damage during transportation due to relative movement between insulation assembly and top dome.

iv) The lowest part of the insulation assembly shall be properly secured to avoid any risk of damage due to transportation stresses.

v) For 0.2S class CT, accuracy shall be maintained between 1% to 120% of rated current.

vi) CTs shall be suitable for high speed auto re-closing (wherever required).

vii) The core lamination shall be of cold rolled grain-oriented silicon steel or other equivalent alloys. μmetal or nano- crystalline core may also be used for metering core to meet the required accuracy. The cores shall produce undistorted secondary current under transient conditions at all ratios with specified parameters.

viii) Polarity marks shall indelibly be marked on each instrument transformer and at the lead terminals at the associated terminal block.

ix) The CTs shall be suitable for horizontal transportation. The CTs shall have provision for taking oil samples from bottom of CT without exposure to atmosphere to carry out dissolved gas analysis periodically. Bidder shall give his recommendations for such analysis, i.e. frequency of test, norms of acceptance, quantity of oil to be withdrawn and treatment/corrective actions for CT.

x) Power Factor terminals to measure tan-delta and capacitance shall also be provided.

xi) The rated currents and ratio, the number of secondary cores, accuracy class, burden, secondary winding resistance, knee point voltage, and excitation current shall be in accordance with the requirements of the protection and metering system.

xii) The rated burden of cores shall be closer to the maximum burden requirement of metering and protection system for better sensitivity and accuracy and shall not exceed 30 VA.

xiii) Instrument Security Factor shall be less than five for Current Transformers upto 400 kV voltage class and less than ten for Current Transformers of 765 kV and 1150 kV voltage class.

xiv) The accuracy class for metering core shall be equal to or better than the accuracy class of the meter specified in the Central Electricity Authority (Installation and Operation of Meters) Regulations, 2006.

xv) In case of digital substations, Non-Conventional Current Transformers or conventional Current Transformers with merging units that are interfaced with the process bus and station bus architecture shall be used.

11.6 Terminal / Marshalling box

Secondary terminals of CTs shall be brought out in a weather proof powder coated terminal box. Facility shall be provided for star delta formation, short circuiting and grounding the CT secondary at the marshalling box. All the taps of each core shall be wired to Marshalling Box to facilitate ratio changing. The box shall have a degree of protection IP-55. Tariff metering core terminals (for connecting main and check meters) shall be housed in separate sealable terminal box.

11.7 Insulators/Bushings

Anti-fog polymeric bushing insulators shall be used for housing various equipment. Polymeric Insulators / bushings shall conform to applicable Standards.

The bushing/ insulator shall be one piece without any metallic flange joint.

11.8 Tests

i) The Instrument transformers (CTs, CVTs, EMVTs) shall be subjected to routine test as per IEC in the presence of Purchaser's representative.

ii) Certified copies of reports of type tests carried out on similar type and rating within last five years from the date of submission of Bid shall be furnished to the Purchaser for review and approval.

iii) In case the type test reports are not found to be meeting the specification requirements, the BIDDER shall conduct all such tests under this contract free of cost to the Purchaser and submit the reports for approval.

iv) All Type test certificates should be from Govt. test houses or NABL approved/Govt. approved laboratories unless the same have been carried out by Contractor/Manufacturer at manufacturers premises in presence of 3rd party.

11.9 Isolator motor operated with motor operated earth switch

i) Disconnectors shall be outdoor type. Earth switches shall be provided on isolators wherever called for, with possibility of being mounted on any side of the isolator.

ii) Disconnector design shall be double break or vertical break or knee-type. Disconnectors of lower voltage level shall be counter break or double end break or pantograph type depending on the busbar configuration and switchyard layout.

iii) Disconnector shall be assembled with complete base frame, linkages, operating mechanism, control cabinet, interlocks etc.

iv) Disconnectors and earth switches shall be capable of withstanding the dynamic and thermal effects of the maximum possible short circuit current of the systems in their closed position. They shall be constructed such that they do not open under influence of short circuit current. Further they shall be capable of withstanding the static loads (Longitudinal, transversal and vertical) as per relevant standard.

v) Disconnectors shall be of extended mechanical endurance class - M2 as per standard for voltage class above 72.5KV. Disconnectors less than 72.5kV shall be of class M1. All earth switches shall be of M0 duty.

vi) Disconnectors shall be of low level or high-level type to suit the switchyard layout as required and suitable for single-phase operation.

vii) Pantograph Isolator shall be single pole, off circuit, fault make, vertically mounted type.

viii) The contacts shall be self-aligning and self-cleaning and so designed that binding cannot occur after remaining closed for prolonged periods of time in a heavily polluted atmosphere.

ix) No undue wear or scuffing shall be evident during the mechanical endurance tests. The contact shall be spring less, adjustable, self-aligning high-pressure type. If springs are unavoidable, the contacts and spring shall be designed so that readjustments in contact pressure shall not be necessary throughout the life of the isolator or earthing switch. Each contact or pair of contacts shall be independently sprung so that full pressure is maintained on all contacts at all time.

x) All contact surfaces shall be of silver faced copper.

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xi) All metal parts shall be of non-rusting and non-corroding material. All current carrying parts shall be made from high conductivity electrolytic copper/aluminium. Bolts, screws, and pins shall be provided with lock washers. Keys or equivalent locking facilities if provided on current carrying parts shall be made of copper silicon alloy or stainless steel or equivalent. The bolts or pins used in current carrying parts shall be made of non-corroding material. All ferrous castings except current carrying parts shall be made of malleable cast iron or cast steel. No grey iron shall be used in the manufacture of any part of the isolator.

xii) Isolators and earthing switches including their operating parts shall be such that they cannot be dislodged from their open or closed positions by short circuit forces, gravity, wind pressure, vibrations, shocks, or accidental touching of the connecting rods of the operating mechanism.

xiii) The switch shall be designed such that no lubrication of any part is required frequently. Bidder shall indicate the number of operations after which lubricant is required.

xiv) The live parts shall be designed to eliminate sharp joints, edges and other corona producing surfaces, where it is impracticable corona ring shall be provided. Corona rings shall be made up of aluminium/aluminium alloy.

xv) Material of earthing blades and contacts shall be same as those of main blades and contacts, respectively. The earthing blade shall have the same short time current rating (thermal and dynamic) as that of main blades.

xvi) For Pantograph isolators, shielding is required at the point of connection of lower bus, lower arm end, end of moving scissors assembly, fixed contact assembly etc.

xvii) Isolator or disconnector switch & Earth switch shall be compatible for severe ice condition as required.

xviii) Each single pole of the isolator shall be provided with a complete galvanized steel base provided with holes and designed for mounting on a supporting structure.

xix) Base channels and other structural steel members such as operating pipes, phase coupling rods, operating mechanism boxes, bolts, pins etc. shall be hot dip galvanised.

11.10 Earthing switch

i) Earthing switch shall form an integral part of each pole of the disconnector. Earth switches shall also comply with the requirements as per the standard.

ii) Earth switches of voltage > 245kV shall also comply with the requirements of relevant standard, in respect of induced current switching duty as defined for Class-B and short circuit making capability class E- 0 for earthing switches.

iii) The earthing switches shall form an integral part of the isolator and shall be mounted on the base frame of the isolator.

iv) Each earth switch shall be provided with flexible copper/aluminium braids for connection to earth terminal. These braids shall have the same short time current carrying capacity as the earth blade. The transfer of fault current through swivel connection will not be accepted.

v) The plane of movement and final position of the earth blades shall be such that adequate electrical clearances are obtained from adjacent live parts in the course of its movement between ON and OFF position.

vi) Disconnector design shall be such as to permit addition of earth switches at a future date. It should be possible to interchange position of earth switch to either side. The earth switch should be able to carry the same fault current as the main blades of the Isolators and shall withstand dynamic stresses.

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vii) Flexible copper connections between movable parts of an earthing switch and its frame shall have a cross-section of at least 50 mm².

viii) This minimum value of the cross-sectional area of copper connections is given to ensure mechanical strength and resistance to corrosion. Where the flexible connection is used to carry the short-circuit current, it shall be designed accordingly. If another material is used, a suitable equivalent of cross-section shall be provided.

11.11 Interlocks

i) Disconnector and earthing switch shall be mechanically interlocked such that it will not be possible to close the earthing switch when the disconnector is closed and vice versa. The mechanical interlocks shall be in addition to the electrical interlocks. Suitable mechanical arrangement shall also be provided for delinking electrical drive for manual operation.

ii) Electrical interlocking arrangement shall be fail-safe type. This shall be in the form of bolt interlock comprising an interlock coil of latch-in type to lock the disconnector driving shaft and thus prevent disconnector operation in the latch-in condition. It shall be possible to release the latch by energizing the interlock coil when certain pre-set conditions of PURCHASER's external interlocking scheme are fulfilled. For this purpose, the VENDOR shall provide facilities for wiring PURCHASER's external interlocking contacts both in disconnector opening and closing circuits. Further, a separate bypass switch or a similar facility shall be provided on the local control cabinet to facilitate emergency manual operation of disconnector.

11.12 Operating mechanism and controls

i) Separate motor operating mechanisms shall be provided for isolator & earth switch. The operating mechanism shall be located such that it can be directly mounted on any one of the support structure.

ii) The ganging mechanism shall be provided for 3 pole with sufficient adjustment to allow for final alignment of the disconnector blades for simultaneous operation. Adjustable stops shall be provided to prevent over-travel in both directions.

iii) In case the disconnectors are not ganged three pole type and are with individual pole operation, an operating mechanism shall be provided for each pole. One of them shall work as master and the other two shall be followers. Suitable equipment like master follower switch and related circuitry including derivation of grouped NO and NC contacts at a single box shall be provided. A disagreement circuit shall be incorporated for detecting pole position discrepancy in the operating mechanism.

iv) Arrangement shall be provided to permit manual operation of power operated disconnectors and earth switches. The arrangement shall be such that when manual operating handle is in the engaged position, the power operation is made inoperative. Padlocking facility shall be provided for the manual operating handle. Where disconnector is required to be connected to high level buses, the operating rod shall be provided with guide bearings at an interval of 3 metres.

v) The operating mechanism design shall be such that during the operation of the disconnector, especially manual operation, when the moving blades reach the sparking distance, springs take over to give a quick, snap action closing so that the disconnector closing is independent of manual efforts. Similarly, the springs must assist during the opening operation to give quick breaking feature.

vi) The operating pipes and rods shall be capable of withstanding all torsional and bending stresses due to operation of the isolator. Wherever supported the operating rods shall be provided with bearings on either ends. All bearings shall be weather protected by means of covers and grease retainers. The operating rods/ pipes shall be provided with suitable universal couplings to account for any angular misalignment.

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vii) The operating mechanism / handles / vertical down pipe shall be suitable for mounting on either end of the disconnector and shall not foul with the earthing switch.

viii) The isolator and earth switches shall be provided with "over center" device in the operating mechanism to prevent accidental opening by wind, vibration, short circuit forces or movement of the support structures.

ix) Signalling of closed position shall not take place unless it is certain that the movable contacts, have reached a position in which rated normal current, peak withstand current and short time withstand current can be carried safely.

x) Signalling of open position shall not take place unless movable contacts have reached a position such that clearance between contacts is at least 80% of the isolating distance.

xi) The position of movable contact system (main blades) of each of the Isolators and earthing switches shall be indicated by a mechanical indicator at the lower end of the vertical rod of shaft for the Isolators and earthing switch. The indicator shall be of metal and shall be visible from operating level.

xii) Link mechanism shall have 'Dead centre interlocking' to prevent any change in end position of disconnector due to external forces on the arm (e.g. Earthquake, Short line fault, Wind etc.) even when the drive is de-coupled from disconnector.

xiii) A weather-proof cabinet made of galvanized sheet steel (min thickness of 2mm)/stainless steel (grade 304) of min 2mm thickness/ fibre glass reinforced polycarbonate with gasketed hinged door and padlocking facility shall be provided to house driving mechanism, motor starters, control valve solenoids, auxiliary switches etc., as applicable. All cabling from operating mechanism and auxiliary contacts to operating mechanism box and inter pole wiring shall be carried out using 1100 V grade, 2.5 sq. mm. stranded copper conductor, PVC insulated, armoured, multicore cables or single core cables laid in heavy gauge galvanised steel conduits, unless otherwise specified. Thermostat controlled space heater with ON/OFF switches rated at 230V, 1phase, 50 Hz shall be provided to prevent condensation in the mechanism. Cubicle illumination lamp with door operated switch and convenience receptacle shall be provided. Three phase switch with MCB shall be provided for power supply and a two-way switch with MCB shall be provided for control supply in the motor operated mechanisms of the Isolators.

11.13 Motor Drive

i) For power operated disconnectors, a local/remote selector switch and a set of open/close push buttons shall be provided in the operating mechanism box.

ii) Motors shall be totally enclosed, weather-proof, outdoor type and tropicalised. It shall be suitable for supply variation of ±10% voltage, ±5% frequency and ±10% combined variation, suitable for ambient as specified in project information and with class of insulation 'F'. The motor shall be provided with suitable overload & single phasing prevention protection.

iii) Limit switches for motor control shall be fitted on the disconnector shaft, within the cabinet, to sense open and close positions of the disconnector.

iv) In addition to the limit switch contacts required for control of power operated disconnectors, the number of auxiliary contacts shall be provided. The auxiliary contacts shall be of silver faced copper. The contacts shall be designed to carry 10 A continuously.

v) Adequate no. of spare terminals shall be provided in the operating cabinet for the purpose of external interlocks.

11.14 Insulators

i) Insulators used in the assembly of disconnectors shall be polymer insulator.

ii) The insulator shall conform to relevant standard. Pressure due to the contact shall not be transferred to the insulators after the main blades are fully closed.

iii) Caps and pins shall be of the highest quality malleable iron or forged steel and smoothly galvanized.

iv) All insulators of identical ratings shall be interchangeable.

v) Insulator shall be type and routine tested as per relevant standard. Besides following additional tests shall also be conducted:

a) Bending load test in four directions at 50% of minimum bending load guaranteed on all insulators, as a routine test.

b) Bending load test in four directions at 100% of minimum bending load as a sample test on each lot.

c) Torsional test on sample insulators of a lot.

d) Ultrasonic test as a routine test.

11.15 Accessories

11.15.1 Earthing pads

Each pole of the disconnector shall be provided with two earthing pads of non-corroding material at opposite ends, brazed to the channel base. Flexible tinned copper earth connectors shall be provided for connecting operating handles of disconnectors and earthing switches to the earthing system.

11.15.2 Name plate

A weather-proof and corrosion-proof name plate shall be provided on disconnectors, earthing switches and operating devices. The name plates shall conform to applicable standards.

The nameplates of disconnectors and earthing switches (and their operating devices) shall be marked in accordance with IEC standard.

An earthing switch combined with a disconnector as a single unit does not require a separate nameplate unless it has a short-circuit rating different from the disconnector.

The class marking is mandatory if different from M0 or E0. It may be included into the type of designation to avoid additional space requirement.

The rated bus-transfer current shall be marked on the nameplate of a disconnector having a bus-transfer current making and breaking capability.

The nameplate shall be visible in the position of normal service and installation.

11.15.3 Supporting structures

Supporting structures for disconnectors shall be included in the VENDOR's scope of supply. The VENDOR shall furnish detailed dimensioned drawings indicating weights and all fixing details and relative locations of chassis, operating mechanism box and operating handles etc. Vendor shall also furnish orientation GA showing positions of Main Blades and Earth Blade in open condition along with Control Box.

11.16 SF6 gas insulated – to – air bushings

i) SF6-to-air bushings consist of a hollow insulating cylinder which is attached to a flange on the end of a GIS enclosure.

ii) This insulating cylinder contains pressurized SF6 gas on the smooth surfaced interior and can be exposed to atmospheric air on the outside.

iii) Conductor - The conductor continues up through the center of the insulating cylinder to a metal end plate. The outside of the metal end plate allows for the bolting of an air insulated conductor.

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iv) Gas pressure inside bushings - The SF6 gas inside the bushing is usually the same pressure as the rest of the GIS system.

v) Moisture and contaminant shields or sheds – located on the outside of the bushing, these improve the performance of the bushing in wet or contaminated conditions.

vi) Internal metal shields – these help to control electric-field distribution.

vii) External Shields - higher voltage SF6-to-air bushings also use external shields.

viii) Material of insulating cylinder –are made of a composite consisting of fiberglass epoxy inner cylinder with an external weather shed of silicone rubber.

11.17 Gantry tower structures & equipment support structures.

11.17.1 Design requirements for structures

For design of steel structures loads such as dead loads, live loads, wind loads etc. shall be based on IS:875, Parts I to V.

For materials and permissible stresses IS: 802, Part-I, Section-2 shall be followed in general. However, additional requirements given in following paragraphs shall also be considered.

Minimum thickness of galvanized tower member shall be as follows:

11.17.1.1 Leg members, Ground wire (Members Minimum thickness (mm))

i) Peak members/Main members - 5

ii) Other members - 4

iii) Redundant members - 4

iv) Size and thickness of gusset plate, pack washer and pack plate shall be as per requirement.

v) Maximum slenderness ratios for leg members, other stressed members and redundant members for compression force shall be as per IS-802.

vi) Minimum distance from hole center to edge shall be 1.5 x bolt diameter. Minimum distance between center to center of holes shall be 2.5 x bolt diameter.

vii) All bolts shall be M16 or higher as per design requirement.

11.17.1.2 Step Bolts

In order to facilitate inspection and maintenance, the structures shall be provided with climbing devices. Each tower shall be provided with M16 step bolts 175mm long spaced not more than 450mm apart, staggered on faces on one leg extending from about 0.5 meters above plinth level to the top of the tower. The step bolt shall conform to IS: 10238.

11.17.1.3 Design Criteria

i) All structures shall be designed for the worst combination of dead loads, live loads, wind loads as per code IS:875, seismic forces as per code IS:1893, loads due to deviation of conductor, load due to unbalanced tension in conductor, torsional load due to unbalanced vertical and horizontal forces, erection loads, short circuit forces including “snatch” in the case of bundled conductors etc. Short circuit forces shall be calculated considering a fault level of 40 kA, 50kA, 63kA or as applicable. IEC- 60865 may be followed for evaluation of short circuit forces.

ii) Switchyard gantry structures shall be designed for the two conditions i.e., normal condition and short circuit condition. In both conditions the design of all structures and all assume that stringing is done only on one side i.e., all the three (phase) conductors broken on the other side. Factor of safety of 2.0 under normal conditions and 1.5 under short circuit condition shall be considered for the design of switchyard structures.

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iii) Vertical load of half the span of conductors/string and the earth wires on either side of the beam shall be considered for the purpose of design. Weight of man with tools shall be considered as 150 kgs. for the design of structures.

iv) Terminal/line take off gantries shall be designed for a minimum conductor tension of 4 metric tonnes per phase for 400kV / 220 kV or as per requirements whichever is higher. The distance between terminal gantry and dead-end tower shall be taken as 200 metres for 400kV/220kV as per requirements. The design of these terminal gantries shall also be checked considering +/- 30 deg deviation of conductor in both vertical and horizontal planes. For other gantries the structural layout requirements shall be adopted in design.

v) The beams shall be connected with towers/ columns by bolted joints.

vi) All Pipe support structures used for supporting equipment's shall be designed for the worst combination of dead loads, erection load. Wind load/seismic forces, short circuit forces and operating forces acting on the equipment and associated bus bars as per IS:806. The material specification shall be as per IS: 1161 read in conjunction with IS: 806.

vii) If luminaries are proposed to be fixed on gantries, then the proper loading for the same shall be considered while designing. Also holes for fixing the brackets for luminaries should be provided wherever required.

viii) Foundation bolts shall be designed for the loads for which the structures are designed.

ix) Height of Lightning masts shall be as per approved structure layout and designed for diagonal wind condition. Lightning masts shall be provided with plateforms for mounting lighting fixtures and a structural steel ladder within its base up to the level of plateform. The ladder shall be provided with protection rings. The platforms shall also have protection railing. The details of lighting fixtures would be as per the approved drawings

11.18 Structures designed during detailed engineering:

Design of structure is covered in the scope of contract; hence, the contractor shall submit design along with line diagram for approval and based on approved line diagram, fabrication drawing shall be prepared and submitted for employers' approval. The line diagram should indicate not only profile, but section, numbers and sizes of bolts and details of typical joints. The fabrication drawings to be prepared and furnished by the Contractor shall be based on line diagram designed by contractor and approved by the employer. These fabrication drawings shall indicate complete details of fabrication and erection including all erection splicing details and typical fabrication splicing details, lacing details, weld sizes and lengths. Bolt details and all customary details in accordance with standard structural engineering practice whether or not given by the employer. The fabrication drawings and bill of material based on fabrication drawing shall be submitted to the employer for approval. Approved bill of material prepared based on fabrication drawing shall be the basis for payment. Such approval shall, however, not relieve the Contractor of his responsibility for the safety and durability of the structure and good connections and any loss or damage occurring due to defective fabrication, design or workmanship shall be borne by the Contractor.

11.18.1 Fabrication and erection

The fabrication and erection works shall be carried out generally in accordance with IS 802. A reference however may be made to IS 800 in case of non-stipulation of some particular provisions in IS 802. All materials shall be completely shop fabricated and finished with proper connection material and erection marks for ready assembly in the field.

The component parts shall be assembled in such a manner that they are neither twisted nor otherwise damaged and shall be so prepared that the specified camber, if any, is provided. In order to minimize distortion in member the component parts shall be positioned by using the clamps, clips, dogs, jigs and other suitable means and fasteners (bolts and welds) shall be placed

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in a balanced pattern. If the individual components are to be bolted, paralleled and tapered drifts shall be used to align the part so that the bolts can be accurately positioned.

Sample towers, beams, lightning masts and equipment support structures may be trial assembled in fabrication shop in order to ensure fitment of various members and to avoid problems during erection.

The Contractor should arrange on his own all plant and equipment, welding set, tools and tackles, scaffolding, trestles equipment's and all other accessories and ancillaries required for carrying out erection without causing any stresses in the members which may cause deformation and permanent damage. Minor modification, if any, required during erection shall be done at site with the approval of Engineer – in- charge.

11.18.2 Bolting

i) Every bolt shall be provided with a washer under the nut so that no part of the threaded portion of the bolt is within the thickness of the parts bolted together.

ii) In case of fasteners, the galvanizing shall confirm to IS-1367(Part 13). The spring washer shall be electro galvanized as per Grade IV of IS-1573.

11.18.3 Welding

The work shall be done as per approved fabrication drawings which shall clearly indicate various details of joints to be welded, type of weld, length and size of weld, Symbols for welding on erection and shop drawings shall be according to IS:813. Welding shall be carried out in accordance with IS:816.

11.18.4 Foundation bolts

Foundation bolts for the towers and equipment supporting structures shall be embedded in first stage concrete while the foundation is cast. The Contractor shall ensure the proper alignment of these bolts to match the holes in the base plate. The Contractor shall be responsible for the correct alignment and leveling of all steel work on site to ensure that the towers/structures are plumb. All foundation bolts for lattice structure, pipe structure are to be supplied by the Contractor.

All foundation bolts shall be provided with two no. standard nuts of class 5 confirming to IS:1363/1367/6639, one check nut of class 4 confirming to IS:1364, one anchor plate at the bottom of foundation bolt and one plain washer. All foundation bolts shall conform to IS 5624, however, the material, shall be MS conforming to IS:2062/ SAE:1018.

11.18.5 Stability of structure

The Contractor shall be responsible for the stability of the structure at all stages of its erection at site and shall take all necessary measures by the additions of temporary bracings and guying to ensure adequate resistance to wind and also to loads due to erection equipment and their operations.

11.18.6 Grouting

The method of grouting the column bases shall be subject to approval of employer and shall be such as to ensure a complete uniformity of contact over the whole area of the steel base plate. No additional payment for grouting shall be admissible.

11.18.7 Galvanising

All structural steel works, equipment support structures and foundation bolts shall be galvanized after fabrication. The galvanization shall be done as per requirement of IS 4579. Purity of zinc to be used shall be 99.95% as per IS:209.

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11.19 Bersimis ACSR conductor

11.19.1 Material

i) Aluminium strands of AAC or ACSR conductor shall be hard drawn from 99.5% pure electrolyte aluminium rods with 60% IACS conductivity. The VENDOR shall specify the guaranteed minimum and average values of conductivity. The copper conductor shall consist of hard drawn round copper wires and shall have 97% conductivity. The Annealed copper shall have electrical resistivity of 0.017241 Ohm – mm2/m at 20°C. Hard drawn Aluminium shall have electrical resistivity of 0.028264 Ohm – mm2/m at 20°C.

ii) Chemical composition of the material shall comply with the requirements of relevant Standards.

iii) The surface of conductor shall be clean and dry and free from any excess grease that may be used in its fabrication. The surface strands shall be smooth and free from burrs and other projections which may be cause for increasing corona losses when the conductor is used on extra high voltage lines.

iv) The conductor shall be of heavy-duty type and designed to operate within set temperature limits and to withstand thermal and electromechanical forces developed due to short circuits.

11.19.2 Galvanising

i) The steel wire strands of ACSR conductor and steel conductor shall be hot dip galvanised. Zinc / Zinc alloy coating shall be evenly and uniformly coated complying with relevant standards for heavily coated wires.

ii) The zinc used for galvanizing shall be electrolytic high-grade zinc of not less than 99.95% purity.

11.20 Bus post insulator & disc insulator

11.20.1 Disc insulator

i) The insulator discs shall be cap and ball pin type with Ball and Socket coupling suitable for use in suspension or tension strings. Insulators shall be interchangeable and shall be suitable for forming either suspension or tension string. Normal type disc insulator with Ball and Socket coupling is not acceptable. Anti-fog type disc insulator is to be supplied only.

ii) The insulator shall be high dielectric mechanical and thermal strength, free from internal stresses, blisters, laminations, voids, foreign matters, imperfections or other defects, which might in any way render it unsuitable as insulator shells. The insulator shall be remain unaffected by climatic condition, Ozone, acids, alkalies, zinc or dust.

iii) The insulator shall have a good performance under extreme weather condition of tropical climate and dust resistant. It shall not crack or chip due to ageing under normal service condition or while handling during transit or erection.

iv) When operating at normal rated voltage there shall be no electric discharge between insulator and conductor, which would cause corrosion or injury to conductor and insulator by the formation of substance due to chemical action.

v) The caps and ball pins of Disc Insulator shall be hot dip galvanised in accordance with the latest edition of IS: 2629 and mechanically strong. The Zn used for galvanising shall be of grade Zn 99.95 as per IS: 209. The Zinc. Coating shall be uniform, adherent, smooth reasonably bright, continuous, and free from imperfection such as flux, ash, rust stains bulky white deposits and blisters. The ball pins shall move freely in the cap socket but shall be so designed that they do not disengage while in service. The caps shall be made of heat-treated malleable cast iron. These shall be free from cracks,

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shrinks, air holes, burrs, and rough edges. All load bearing surfaces shall be smooth and uniform so as to distribute loading stress evenly.

vi) The ball pins shall be of forged steel and so designed that they will not yield or distract under loaded conditions. The ball and socket insulators shall be provided with 'R' clip to prevent uncoupling of insulator units from each other. The 'R' clip shall be made of phosphor bronze or stainless steel to safe guard against corrosion.

vii) The electrical and mechanical characteristic of the Disc Insulator shall conform to specific technical parameters of this specification and relevant Indian Standards. Each Insulator shall have rated strength markings on porcelain printed and applied before firing.

viii) Tension insulators are to be anchored to the girders of sub-station gantries at suitable height and intervals depending upon the different voltage classes. No. of insulator strings to be provided for high level bus connections/phase shall be as per approved layout design.

11.21 Post insulator

i) The porcelain used shall be homogeneous, free from lamination, cavities thoroughly verified smoothly glazed and type of post insulator shall be solid core. The glaze shall be of uniform brown in colour. The glaze shall cover the exposed porcelain parts of the insulator. Glazing shall be free from blisters, burrs etc.

ii) The post insulator shall be designed and manufactured to avoid stresses due to expansion and contraction which may lead to deterioration, stress concentration due to direct engagement of porcelain with metal fittings and shapes which do not facilitate cleaning by normal methods.

iii) Cement used in the construction of insulators shall not cause fracture by expansion or loosening by contraction and must have high compressive and shearing strength and free from change in volume due to ageing and temperature change. The cement shall not give rise to chemical reaction with metal fittings. Rapid hardening cement with special sand shall be used for assembly of metal parts. When operating at normal rated voltage there shall be no electric discharge between insulator and conductor, which would cause corrosion or injury to conductor and insulator by the formation of substance due to chemical action.

iv) All ferrous metal parts except those of stainless steel shall be hot dip galvanised and uniform zinc coating shall satisfy the requirement of IS:2633. The Zinc used for galvanising shall be grade Zn 99.95 as per IS:209. The zinc coating shall be uniform, adherent smooth, reasonably bright, continuous, and free from imperfection.

v) The tapped holes suitable for bolts with threads shall have anti-corrosion protection. The effective length of the thread shall not be less than the nominal diameter of the bolt.

vi) The electrical and mechanical characteristics of post insulator shall conform to the specific technical parameters of this specification and relevant Indian Standards.

vii) Post Insulator shall be suitable for upright mounting on steel structures.

11.22 Hardware fittings for insulator string

i) General design of hardware fittings shall be such as to ensure uniformity, high strength, and freedom from corona formation and high resistance against corrosion.

ii) The materials of the fittings shall be so selected that yield strength of the material shall not be less than maximum working load.

iii) All shackles, fasteners, eyes, suspension and tension clamp and other fittings for attaching insulators to the Gantry tower, A-frame & other sub-station structure with conductor shall be so designed as to reduce any damage to conductor, insulator &

hardware fittings. Anchor shackles, Ball hook, Ball eye, Ball clevis, Ball link, Socket clevis, Yoke plates, Arcing horn, turnbuckle, jumper cone. Comp. Dead end assembly Bolted type suspension clamp etc. shall be supplied as per requirement.

iv) The materials for various hardware accessories shall conform to IS:2486.

v) All ferrous metal parts, which will be exposed to the atmosphere in service, shall be protected by hot dip galvanizing.

vi) All forgings and castings shall be of good finish and free from flaws and other defects. The edges on the outside of fittings such as the eye, clevis and holes shall be rounded.

vii) All parts of different fittings which provide the inter connection shall be made such that sufficient clearance is provided at the connection point to ensure free movement and suspension of the insulator string assembly. Suspension clamps shall be so designed that the effects of vibration both on conductors and fitting itself are minimised. The clamp shall permit the conductor to slip before the failure of the conductor occurs. The fitting shall have sufficient contact surface to minimise damage due to fault current.

viii) The Hardware fittings for Suspension and Tension string shall be supplied complete in all respect.

ix) The suspension hardware is to be used with normal (B-type) disc insulator having Electro-mechanical Strength of 70 KN for all voltage classes except 400KV and tension hardware are to be used with normal. (B-type) disc insulator having Electro-mechanical Strength of 120 KN for 220 KV, 132 KV & 33 KV voltage class & 160KN for 400KV voltage class. For 400KV suspension string Disc insulator with normal (B) type disc insulator having electromechanical strength of 120KN shall be used.

x) Suspension and tension hardware shall be suitable for insulator with nominal pin shank diameter of either 16 mm. or 20 mm. as per approved 12KV Class Disc insulator to be utilised at sub-station. Unless specifically mentioned the tension clamps shall be of compression dead end type and shall have a steel sleeve to be compressed on the steel core end of the conductor.

xi) Sag compensating spring shall be within the scope of supply by the Contractor for 400 KV Main I, Main II and Transfer Bus. Design calculation of the springs are to be submitted during detailed Engineering

xii) Suspension clamp shall be of Armour Grip type.

xiii) Design of fittings shall be such as to avoid local corona formation or discharges and shall have smooth finished surface of all parts.

11.23 Tests

i) Routine tests and acceptance tests as per the applicable standards shall be carried out for the items included in the scope in the presence of PURCHASER's representative.

ii) Type tests, if specified shall also be carried out as per relevant standards. Valid type test reports of similar equipment for all the type tests as per standards shall be submitted for purchaser's review & approval. The type test reports shall be less than 5 years old and should have been carried out at a reputed independent national / international laboratory OR witnessed by an independent authorized & approved third party inspector. If valid type test reports meeting the above requirements are not available, it is mandatory that type tests as per standards shall be carried in presence of purchaser without any extra cost and time implication.



11.24 Employer's Specifications

Sl. No.	Description	Unit	Technical Data
1	Nominal system voltage	kV	400
2	Highest system voltage	kV	420
3	Number of phases	-	3 Ph
4	Frequency	Hz	50
5	Design ambient temperature	o C	50
6	One minute power frequency withstand voltage at_____hz.	kV(RMS	695
7	Rated 1.2/50µs lightning impulse withstand voltage (BIL)	kV peak	1425
8	Short circuit withstand current, duration and system		63 KA for 3 sec

11.25 Mandatory Spares

Sl. No.	Items	Unit	Qty.
1	**Pot Head Yard**		
1.1	Disc Insulators	5% of the total number of discs of each voltage class installed at the substation/switchyard.	
1.2	Long Rod Insulator	5% of the total number of insulators of each voltage class installed at the substation/switchyard, subject to a minimum number of three insulators of each voltage class.	
1.3	Conductor accessories and hardware	Quantity shall be commensuration with the spare for conductor and insulators.	
1.4	Complete **Potential Transformer** / Capacitor Voltage Transformer with terminal connectors & structure	Nos. of each rating	2
1.5	**SURGE ARRESTOR** Complete Surge Arrester with insulating base and Terminal connector & structure	Nos. of each rating	2
1.6	**Post Insulator**	Nos. for each voltage rating	3
2.	**Double Break Isolators**		
2.1	One complete pole including support Insulator, motor operating mechanism and terminal connector but excluding structure	Two (2) complete isolators of each voltage class, and highest short-time and normal current rating (along with support structure) available at any of the substations	
2.2	Isolator Arms with finger contacts and current carrying assembly	Set	1
2.3	Support Insulators	Set	1
2.4	Copper contact fingers for male & female contacts	Set s	2
2.5	Open / Close contactor assembly, timers, key interlock push button switch & auxiliary switches	Set s	2
2.6	Limit switch	Sets	2
2.7	Motor housing bearing assembly	No.	1
2.8	Terminal Pads and connectors	Sets	2
2.9	Motor with gear assembly and bevel gear assembly	No.	1
2.10	Corona shield rings	Nos.	3
2.11	Hinge pins	Nos.	3
2.12	Bearings	Set	1
2.13	Interlocking coil with resistor	Nos.	5
2.14	Fuses of each rating	Nos.	5



CHAPTER 12: COOLING WATER SYSTEM

12.1 Scope of Work

Scope of work under this Chapter covers the provision of labour, tools, plants, materials and performance of work necessary for the design, manufacture, quality assurance, quality control, shop assembly, shop testing, delivery at site, site storage and preservation, insurance installation, commissioning, performance testing, acceptance testing, over to KHPL and guarantee for three years of cooling water system, as per the specifications here under, each complete with all auxiliaries, accessories, spare parts and warranting a trouble free safe operation of the installation. The Systems shall be suitable for Ambient, Seismic, Altitude and other site conditions as detailed in General Technical Specifications.

The scope of work shall be a comprehensive functional system covering all supply and services including but not be limited to following:

12.1.1 Cooling Water System Equipment

i) Eight (8) nos. horizontal centrifugal pumps for cooling water circuit along with local control panel, instrumentation and associated accessories etc.

ii) Four (4) nos. Filters/Strainers (one per pump circuit).

iii) Six (6) nos. heat exchangers complete with associated accessories (including 2 nos. standby).

iv) Make up water tank along with necessary interconnected piping for bringing the potable/clean water to the cooling water system in the powerhouse. The makeup tank shall be fed from outdoor RCC tank.

v) Necessary piping arrangement for bringing the makeup & clean water from the overhead tank to the Powerhouse for reactor, HVAC and turbine runner cooling & makeup water for cooling water system.

vi) Required anti scalant dosing system if required shall be provided.

vii) Two (2) nos. submersible pumps with filters, automatic motorized strainers, piping, valves, etc. for filling outdoor RCC tank for station services, HVAC system.

viii) Insulation with vapour proof cladding for exposed pipes, wherever applicable.

ix) Necessary valves, piping, Y-filters, air scouring arrangements, regulating orifices, all type of consumables and other materials.

x) Necessary instrumentation pressure gauges, pressure switches, pressure transmitter, flow indicator, flow relay/ transmitter, and temperature gauges, temperature switches, temperature transmitter etc.

xi) All power cables, control cables and special cables, cable racks, cable glands, lugs, terminals, connectors etc. for cabling between equipment and devices covered in this chapter,

xii) Coordination and provision of necessary contacts and / or ports for integration with plant SCADA system,

xiii) Spare parts in accordance to clause 10.12 “Spare Parts” of this Chapter.

xiv) Tools and instruments in accordance to clause 10.14 “Tools and Instruments” of this Chapter.

Any other item(s) not mentioned specifically but necessary for the satisfactory completion of scope of work defined above, as per accepted standard(s)/best international practices.

12.2 Specific Design and Layout Conditions

The cooling water requirement of all the generating units & transformer banks shall be made closed loop of potable cooling water circuit. The single line diagram of cooling water system has been shown in drawing no. KHPP-ME-6017-PI-60005.

Two sumps (one between tail races of U#1 & U#2 and other between U# 3 & U#4) shall be provided to accommodate two heat exchangers.

Similar philosophy shall be adopted for 3 nos. heat exchangers placed in pit 2 for U # 3 & U #4. The flow through heat exchanger circuit is be governed by the motorized valve placed in their circuit. Filters & centrifugal pumps shall be installed in two groups at two different locations, one between U#1 & U#2 and other between U# 3 & U#4.

The cooling water tank shall be used to meet the requirement of cooling circuit of HVAC system, reactor and turbine runner cooling

Water for generator air coolers, bearing oil coolers and transformer oil cooling system shall go through a distribution manifold to each cooler and water returns to a collecting manifold.

The system shall be provided with check valves, flow meters, isolation valves and necessary instrumentation, which shall be finalised during detailed engineering to fulfil the intended duties and control philosophy. Necessary gate valve with motorised valves in series shall be provided in filter suction side for isolation and auto controls. The common cooling water header shall have isolating valves to facilitate maintenance of cooling water system.

The cooling water circuit of HVAC system as well as requirement of firefighting system shall also be made from cooling water sumps of tailrace & bore well pumps in the pothead yard. Provision for two tappings from each interconnecting headers of sumps shall be made, one for HVAC primary cooling water pump and one for firefighting pump.

One pump shall be provided in each pit and common header shall connected to overhead tank water. Pumps shall be sized to supply water required for fire protection system, cooling water system, HVAC, portable and service water requirements.

12.2.1 Design Considerations

The project is situated in Himalayan region where the silt content during high flow period is excessive and peaks abnormally. Cooling water filters, and pumps may be expected to handle water with silt concentration up to 3000 ppm during high flood.

The Contractor shall critically study the silt data and chemical analysis of water and take the same into account in designing the cooling water system susceptible to abrasive effect of silt, making all such specific provisions and measures including selection of materials, surface coating, corrosion protection/ painting which will help to resist silt erosion/abrasion and enable easy and quick maintenance/replacement of worn out components.

The cooling water system shall be suitably designed so that even during synchronous condenser mode operation of generating units, cooling water supply shall be made available continuously to runner, seals, labyrinths etc., and to all required parts of the system. Necessary arrangements shall be provided accordingly.

12.3 Standards

The CW equipment shall be manufactured and tested in accordance with applicable Indian standards or equivalent international standards. List of some of the relevant major standards is given below. Latest version of these standards shall be applicable.

i) IS: 325 : Three phase Induction motor
ii) IS: 1394 : Low voltage switchgear.
iii) IS: 2062 : Steel for general structural purposes
iv) ANSI B36 : SS Piping

v) ASME B16.9 : SS Pipe fittings

Equipment and materials conforming to any other standard, which ensures equal or better quality, may be accepted subject to approval of the Owner. In such case, copies of the English version of the standards adopted shall have to be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules, Central Electrical Authority's rules and regulations as amended up to date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

12.4 Rating and Functional Characteristics

12.4.1 Cooling system

The capacity of the cooling system shall be designed to meet the requirements of the following major equipment for each unit:

i) Generator air coolers,

ii) Generator thrust bearing oil coolers,

iii) Generator guide bearing oil coolers,

iv) Turbine guide bearing oil coolers,

v) Generator step up transformers oil coolers,

vi) Bus Reactor oil Coolers,

vii) Governor OPU's,

viii) Any other water requirements.

The design capacity of the above systems shall have a minimum safety margin of 15% over and above the water requirement at maximum continuous rating (MCR) and minimum 10% safety margins in the pump head selection with respect to static head and head loss in the circuit.

The design of the cooling water system shall be such that temperature rise for generator air temperatures, bearing oil temperatures, and transformer winding / oil temperatures shall not exceed the temperature rises specified in the relevant sections of the "Particular Technical Specifications (PTS)".

Filter shall be designed for cold water working pressure rating of at least 7 bars. The valves, piping, fitting, instrumentation and regulating orifices shall be selected for at least cold water working pressure rating of PN16. However, the design pressure of the equipment, pipe, fittings etc. shall not be less than the maximum shut off head of selected pumps with suitable margin.

Some of the basic data which are to be adopted for design of the cooling water system, but shall not be limited to, are as follows:

i) Maximum design cooling water temperature rise of 5ºC,

ii) Fluid velocity in the pipes normally shall not exceed 2.5 m/s,

iii) Suitable pump heads as per the schematic / layout.

12.4.2 Pumps

Each cooling water pump shall be of sufficient capacity to cater the hundred percent (100%) requirement of cooling water for one complete generating unit including three single-phase generator step-up transformers operating at maximum load.

12.4.3 Strainer

The Strainer shall be of sufficient capacity to match the capacity of the cooling water. The strainer shall be provided with free flow area of at least three (3) times of pipe cross-sectional area.

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12.4.4 Heat Exchanger

The heat exchanger shall be of sufficient capacity to match the capacity of the cooling water pumps. The equipment must have proven performance in treating water with high abrasive silt content.

12.4.5 Make up Water Tank

The make-up water tank shall be of sufficient capacity to meet the leakage water requirement of closed-circuit cooling water system

12.5 Performance Criteria & Guarantees

The cooling water system along with all auxiliaries and accessories shall be capable of performing intended duties under specified conditions. The Contractor shall guarantee the reliability and performance of the individual equipment as well as of the complete system specified in Data Sheets of Volume-6.

12.6 Design and Construction

12.6.1 Strainers

The strainers shall be suitable for continuous duty. The strainer shall comprise of stainless steel candles and shall have cast steel body. One (1 No.) drain valve which shall operate on the basis of differential pressure shall be provided.

The strainers shall be capable of removing particles of size 100 micron and above. The pressure drop across the strainers shall be less than approximately 0.2 bar. Adequate sensing arrangement shall be provided to sense the pressure drop across the strainer for further integration with plant SCADA system. Required number of pressure measurement instruments shall also be provided for each strainer.

12.6.2 Pumps

The cooling water pump shall be horizontal centrifugal pump. The material of the pump impeller and casing shall preferably be stainless steel (or better) and cast steel/grey cast iron respectively. The selected impeller material shall have excellent corrosion resistance properties. The pumps shall be complete with continuous duty electric motors with class F insulation (temperature rise limited to class B), control panels, anchor bolts and other mounting materials complying with suitable Indian and International Standards. The motor shall be suitably sized to drive the pump continuously over the specified characteristics without getting overloaded. The Motors shall be suitable for 415V ± 10%, 50Hz ± 5% with contacts for remote operation / indication.

The speed of pumps shall not be more than 1500 rpm.

Electromagnetic type flow switches with suitable nos. of potential free contacts for alarm/ protection shall be provided. Shut-off valves and check valves shall be provided to allow disconnection and switching of each pump without emptying pipes.

Adequate arrangement shall be provided to prevent the pump from rotation in reverse direction.

12.6.3 Heat Exchanger

Heat exchanger shall be tube type capable of transferring all the heat gained during the circulation through various coolers to raw water.

Material of the tubes shall be stainless steel (ASTM A 316 or better) and need to be suitable for prevailing water conditions. The pressure drop across heat exchanger shall not exceed 0.5 bar. The design of heat exchanger shall be based upon the temperature rise mentioned in the PTS. The heat exchanger shall be provided with flanged connections for cooling water inlet and outlet. Temperature indicators, temperature transmitter, differential pressure switches & gauges shall be provided at the inlet and outlet, water side of the heat exchanger for visual local and remote indication and alarm.

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12.6.4 Distributing and Collecting Manifolds

A distributing and collecting manifold shall be provided for each unit. Flow meters with suitable no. of potential free contacts for alarm and protection purpose shall be provided for each cooler according to required parameters shall be located on the collecting/ distributing manifold.

12.6.5 Make Up Tank

The potable water system shall be provided with a common make up water tank of suitable capacity. The tank shall be provided with an automatic filling valve in the filling line and level switch, level gauge and level transducer for local and remote alarm/indication. All other required instrumentation, connections etc. as required, shall also be provided.

12.6.6 Electro Magnetic Water Flow Indicator cum Transmitter

Electro Magnetic water flow indicator cum transmitter shall be provided in each cooling water circuit. All flow transmitter shall be provided with suitable numbers of independent, adjustable, potential free contacts for low flow alarm and protection purposes.

12.6.7 Pressure Transmitter

Pressure transmitter shall be provided in each cooling water pump discharge line and also in each cooling water circuit.

12.6.8 Temperature Transmitter

Temperature transmitter shall be provided in each cooling water pump discharge line and also in each cooling water circuit.

12.6.9 Valves and Piping

All embedded and exposed piping shall be of seamless stainless steel conforming to ASTM 304. The piping and valves shall be in accordance with the “Piping, Fittings, Valves and Heat Exchangers” of GTS.

All required pipes, valves, flanges, fittings, supports, fasteners, and related material shall be supplied as part of this contract. Valve body of all type of valves shall preferably be of cast steel except smaller valves (50 mm and lower) for which the material shall be stainless steel.

12.6.10 Motorized Valve

Motorized valve, operated with three phase AC supply, shall be provided at the inlet of cooling water. The automatic operation/switchover of the circuit shall be effected with the chocking/fault of the self-cleaning filters, pumps and/or duty cycle etc. or to meet any control and automation philosophy, if required.

Humidity control in the motor shall be provided through suitable enclosure and heaters with thermostat switches. The motorised valve shall also be provided with hand wheel for manual operation and it shall be independent of the motor drive.

12.6.11 Insulation for Piping

Wherever applicable, exposed cooling water supply piping shall be insulated against condensation with approved type insulation/lagging with vapour proof cover. The cover shall be painted in accordance with approved colour code.

12.6.12 Control and Monitoring

The cooling water system and associated accessories/equipment shall also be controlled and monitored by the SCADA system.

12.6.12.1 Control

The pumps shall be controlled and monitored at three levels:

i) By respective local control cubicles,

ii) Local Control Board for common services,

iii) Computerized control and monitoring (SCADA) system through Local Control Board for common services.

Facility for selection of control either from Local Control Cubicle or Local Control Board or plant SCADA system shall be provided in the Local Equipment Panel or Local Control Board.

The Contractor shall make provision of contacts and/or ports in local control cubicles for interfacing with SCADA system for control and monitoring. The Contractor shall provide and install all the sensors and operating devices necessary to fulfil the functional requirement of the specification for control system.

Following local controls, but not limited to, shall be provided for each cooling water pump:

i) Remote/local selector switch,

ii) Start / stop push buttons,

iii) Lamp test push buttons,

iv) Any other provision required.

Following local controls, but not limited to, shall be provided for each motorised valve:

i) Remote / local selector switch,

ii) Open/ close push buttons

iii) Lamp test push buttons,

iv) Any other provisions required,

Following automatic controls, but not limited to, shall be provided for each cooling water circuit:

Automatic changeover of circuits in case of hydraulic or mechanical faults in pumps, filters, and/or duty cycle etc.

Running time control with change of sequence to equalize running time,

Provision of necessary contacts/ports for control, monitoring, supervision and annunciation functions shall be made for duplicating these functions in plant SCADA system.

12.6.12.2 Indication and Alarm

The Contractor shall supply suitable instruments and gauges for achieving desired control logic. Indicating instruments as required shall be installed on local control panel and indications may be replicated in Local Control Board/control room for common services.

Following indications, but not limited to, shall be provided for each cooling water pump:

i) Pump running,

ii) Pump stopped,

iii) Water no flow,

iv) Any other indication and alarm required.

Following indications, but not limited to, shall be provided for each motorised valve:

i) Valve open,

ii) Valve opening/ closing,

iii) Valve close,

iv) Motor fault.

v) Any other indication and alarm required

12.6.12.3 Protection

The motor for each pumping unit shall be provided with at least the following device:

i) Over load protection,

ii) Under voltage protection,

iii) Single phasing protection,

12.6.12.4 Instrumentation

List of instruments to be furnished with cooling water system is given in Table below. However, the list is indicative only and scope shall be as per approved drawings/bill of materials during detail engineering to achieve the intended duties and control philosophy.

Sl. No.	Parameter	Type of Instrument	Quantity
	Delivery side of cooling water	Pressure gauge	One (1) per pump
	Suction side of Strainer	Pressure gauge	One (1) per filter
	Differential pressure across Strainer	Differential Pressure gauge and switch	One (1) per filter
	Delivery side of Strainer	Pressure gauge	One (1) per filter
	Cooling water flow in outlet from header	Electromagnetic type flow meter & switch	One (1) per outlet from cooling water header
	Cooling water flow indication at pump outlet	Electromagnetic water flow switch	One (1) at outlet
	Differential pressure across the heat exchanger	Differential Pressure gauge & switch	Two (2) per heat exchanger
	Temperature on both sides of heat exchanger	Temperature gauges and temperature transmitter	Four (4) per heat exchanger

12.7 Inspection & Tests

12.7.1 Shop Tests

The pump, pipes and valves shall be routine tested as per relevant IEC/IS at the works' of Contractor. The Contractor is required to submit type test report and routine test reports of equipment.

12.7.2 Type Tests

Type tests verify that cooling water pumps, motors, filters, valves and control panels perform satisfactorily at the rating assigned. This equipment proposed according to these specifications shall be type tested at typical units in accordance with the relevant Indian/ International standards.

The type tests may not be mandatory if similar typical units have been type tested and test certificate(s) for relevant tests are accepted by the Owner.

The Contractor shall prepare written documents, in a form agreed upon by Contractor and the Owner, of all test certificates/results and hand over these documents to the Owner in due times for review and acceptance. The Contactor shall conduct the type tests, for which certificate are not acceptable, at his own cost.

12.7.3 Routine Tests

These shall include at least the following:

i) Routine tests on all the type of filters, Valves as per relevant Indian/International standards,

ii) Control system equipment/ components shall be tested in accordance with applicable Indian/International standards including insulation tests.

12.7.4 Field Tests

After installation of all equipment the complete systems shall be leakage tested as per field test in general technical specifications as per IEC/IS. If the systems are tested in sections, it applies for each section. All tests to demonstrate operational capabilities as per the intended requirements shall also be done.

The contractor shall furnish a complete outline of the proposed methods and procedures to be followed for field testing, including a list of equipment and instruments to be used, to the Employer's representative for review at least 60 days before the scheduled testing.

All test equipment and instruments shall be furnished by the contractor and will remain the contractor's property after the fulfilment of all tests.

The contractor shall furnish a complete report of the field tests of the equipment.

The tests at site should at least include the following:

i) Pressure test of all field installed piping at 1.5 times of the design pressure,

ii) Leakage test of all field piping,

iii) Opening and closing of valve,

iv) Operation of all controls including the mechanical locking device,

v) Other tests as deemed necessary by the Engineer.

All necessary materials and labour for performing all the above tests shall be provided by the contractor.

12.7.5 Test Reports

Shortly after completion of the field acceptance tests the Contractor shall prepare and forward draft copies of the field acceptance test report to the Employer for review. After review and acceptance, the contractor shall furnish six (6) copies of the final report.

12.8 Quality Control and Assurance

The Contractor shall submit detailed Quality Assurance Plan and Inspection Schedule for Employer’s review and approval in accordance to clause 12 of General Technical Specification.

12.9 Drawings, Documents and Design Calculations

12.9.1 Design Memorandum

The Contractor shall submit to Employer a design memorandum prepared in accordance to clause 2.5 “Design Memorandum” of General Technical Specifications.

12.9.2 Drawings and Documents

The Contractor shall submit all the drawings and documents in accordance with requirements stipulated in clause 2.6 “Drawings & Documents to be supplied by Bidder” of General Technical Specification.

12.9.3 Design Calculation

The Contractor shall submit the design calculation in accordance to clause 2.6.4 “Design Calculations” of General Technical Specifications covering at least the following, for review/ acceptance.

i) Basis of selecting the pump capacity and discharge head,

ii) Basis of size selection of strainer, heat exchanger etc.

iii) Basis of size selection of make-up water tank & clean cooling water tank,

The Contractor shall also provide other calculations as required by the Employer for acceptance of the Contractor’s design.

12.10 Delivery, Installation and Commissioning

The Contractor shall follow the general requirement of Delivery, Installation and commissioning as per relevant clause in GTS.

12.11 Schedule of Requirement

The scope of supplies and services shall be as per various clauses of the technical specifications and supplier shall be responsible to ensure completeness of supplies and services even if these are not fully covered under this clause.

Any item of supply not explicitly listed but otherwise implied by the contents of the specification or essential for smooth operation of the equipment shall be construed as forming part of the supply and no additional charges shall be payable for the same.

The broad schedule of requirements is given in clause 10.1.1 “Scope of Work”.

12.12 Spare Parts

Recommended spare parts shall be supplied in accordance to clause 3 “Spare Parts and Tools” of General Technical Specifications. Specified spare parts to be supplied under this Chapter are as follows.

Sl. No.	Description	Unit	Qty
1	Cooling water pump		
1.1	Complete pump with motor	no.	1
1.2	Impeller	nos.	3
1.3	Wear rings set	nos.	3
1.4	Pump mechanical seal	nos.	2
1.5	Motor bearings	nos.	3
1.6	Pump bearings	nos.	3
1.7	Set of seal and gasket for pump	nos.	2
2	Strainer		
2.1	Set of complete wire filter element assembly as per design	nos.	2
3	Heat Exchanger	no.	1
4	Gaskets of heat exchanger	nos. each	20
5	Valves of size 80 mm and above	nos. of each type	2
6	Pressure gauges and pressure switches	nos. of each type	2
7	Flow meters and flow switches	nos. of each type	2
8	Temperature gauges and temperature transmitter	nos. of each type & size	2
9	Motorized valves of each type along with motor/ panel and other accessories	nos. of each type & size	2

Besides above, the Contractor shall recommend any additional spare parts, which in his opinion are necessary for satisfactory operation of the system. However, the procurement of these recommended spares shall be at the discretion of the purchaser. The additional recommended spare parts shall be indicated in the Data Sheets of Volume-6.

12.13 Guaranteed & Other Technical Particulars

The Contractor shall follow the Guaranteed & Other Technical Particular requirements specified herein and separately in Data Sheets of Volume-6.

12.14 Tools and Instruments

The Contractor shall supply all necessary tools and Instruments etc. for installation, repair and maintenance in accordance to clause 3.2 of GTS.

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12.15 Special tools

The Contractor shall list and supply all special tools. List of such tools including their make and detailed specification, shall be submitted for acceptance by the Employer.

12.16 Deviations from Specifications

All deviations from these specifications shall be separately listed in the requisite Performa of the bid document, in the absence of which, it will be presumed that the provisions of the specifications are fully complied with by the bidder. However, the deviations, which are better than the specifications shall be considered by the purchaser.

12.17 Completeness of Contract

Any fittings, accessories or apparatus required for successful commissioning though may not have specifically mentioned in the specification but are usually necessary for the completeness of the works shall be deemed to be included in the specification and shall be supplied by the bidder without any extra cost to the purchaser.

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CHAPTER 13: LP COMPRESSED AIR SYSTEMS

13.1 Scope of Work

Scope of work under this section covers the provision of labour, tools, plants, materials and performance of work necessary for the design, manufacture, quality assurance, quality control, shop assembly, shop testing, delivery at site, site storage and preservation, insurance, installation, commissioning, performance testing, acceptance testing, handing over to KHPL and guarantee for three years of compressed air systems, as per the specifications hereunder, each complete with all auxiliaries, accessories, spare parts and warranting a trouble free safe operation of the installation. The Systems shall be suitable for Ambient, Seismic, Altitude and other site conditions as detailed in General Technical Specifications.

The scope of work shall be a comprehensive functional system covering all supply and services including but not be limited to following:

13.1.1 Low Pressure (LP) Compressed Air Systems

i) One (1) sets of LP compressors complete with associated accessories for air supply to generator braking, fire protection, service air supply points, other permanent/ temporary installations, purging operation for cyclone separator / strainers etc.

ii) Two (2) sets of LP air receiver complete with manhole/ hand-hole and flanged/ screwed connections for inlet, outlet, safety, instrumentation and other purpose.

iii) Two (2) sets of air dryers complete with associated accessories.

iv) Two (4) sets of LP air receiver complete with manhole/ hand-hole and flanged/ screwed connections for inlet, outlet, safety, instrumentation inline to the unit Pneumatic Generator Brakes (unit dedicated).

v) Service air hoses of length 30 m with necessary connectors etc. located in wall mounted service air enclosure as per approved drawings.

vi) Pipes, valves, fittings, automatic moisture traps, drain connections, air filters, oil filters, required for the systems.

vii) All pressure gauges, pressure switches, pressure transducers, temperature indicators, temperature switches, flow indicator, moisture indicator and any other instrumentation required for the system.

viii) All power cables, control cables and special cables, cable racks, cable glands, lugs, terminals, connectors etc. for cabling between equipment and devices covered in this chapter,

ix) Coordination and provision of necessary contacts and/or ports for integration with plant SCADA system.

x) Spare parts in accordance to clause 12.12 “Spare Parts” of this section.

xi) Tools and Tackles in accordance to clause 12.14 “Tools and Instruments” of this section.

Any other item(s) not mentioned specifically but necessary for the satisfactory completion of scope of work defined above, as per accepted standard(s)/best international practices.

13.2 Specific Design and Layout Conditions

13.2.1 Layout and General Arrangement

LP compressed air systems shall be located at auxiliary bay floor in the Powerhouse.

The generator brake control panels shall be located along the face of the generator barrel. Necessary valves along with by-pass piping shall be provided to run any combination of air compressor and dryer.

The layout of the LP service air headers shall be designed to suit the air requirement of various systems.

13.2.2 Low Pressure (LP) Compressed Air System

The LP compressed air system shall cater the air requirement for generator brakes, various instrumentations and station service requirement on various floors of powerhouse as shown in schematic diagram no. KHPP-ME-6017-PI-60004 for "LP compressed air system".

The rated pressure of LP system shall be 8.5 bars approximately.

The system shall comprise of two (2) sets of LP compressors, two (2) LP air receivers and two (2) air dryers and four (4) unit dedicated air receivers along with necessary auxiliaries. The compressors shall have local control cubicles for control of compressors.

The Station Service air will be distributed through the wall mounted service air enclosures located as shown in the drawing no. EM-108:

Sufficient nos. of service air points in Cable tunnel & ventilation tunnel.

Any additional connections/service air points felt necessary during detailed engineering shall be provided without any extra cost.

13.2.3 Air Quality

Characteristics of the delivered air shall be compliant with relevant Indian or International standard for air in working areas, dry, de-oiled, dusted regulation air.

13.3 Standards

The system and equipment shall be designed, built, tested and installed to the latest revisions of the following applicable standards. In the event of other standards being applicable they will be compared for specific requirement and specifically approved during detailed engineering for the purpose:

Sl. No	Standard	Description
1	IS 6206	Guide for selection, installation and maintenance of air compressor plants with operating pressures up to 10 bar
2	IS 7938	Specification for air receivers for compressed air installation
3	IS 11780	Code for selection and testing of rotary screw air compressor (Oil Flooded)
4	IS 12258	Technical supply condition for air screw compressor (Oil Flooded) for general purpose and industrial applications
5	ISO 8573-1	Rules for Air Quality
6	ASME Section VIII	Pressure Vessel Code

All equipment items shall be designed to operate at the rated characteristics of the installation in continuous mode. The system shall allow maintenance of various system elements without affecting service continuity. The ambient conditions, moisture, temperature and seismicity shall be taken into account for the design, operation and installation of the equipment.

Generally, the equipment construction shall be according to current Indian or International rules and standards.

13.4 Rating and Functional Characteristics

13.4.1 Designed System Pressure

The low-pressure systems shall be designed at 10 bar.

13.4.2 Capacity of Compressor

The rated capacity of each compressor of LP compressed air system shall be such that normally one compressor shall meet the total requirement of the system and second compressor shall be

kept as standby. However, control philosophy shall be designed to run both the compressors in case of emergency.

The minimum rating of the LP air compressor shall be 180 m3/hr (FAD). However, the Contractor needs to submit the LP compressor rating selection calculation.

13.4.3 Capacity of Receiver

The minimum capacity of common LP air receivers shall be 5 m3 and for master generator braking receiver shall be 2 m3 However, calculation for selection of the air receivers needs to be submitted.

13.4.4 Capacity of Air Dryer

The minimum capacity of each air dryer shall be twice the capacity of each compressor so that one dryer can dry the air during running of both the compressor.

13.5 Performance Criteria and Guarantees

The low pressure (LP) compressed air system along with all auxiliaries and accessories shall be capable of performing intended duties under specified conditions and as specified in Data Sheets of Volume-6. The Contractor shall guarantee the reliability and performance of the individual equipment as well as of the complete system.

13.6 Design and Construction

13.6.1 Compressors

Each compressor shall be rotary screw type (Oil flooded type), heavy duty, noise-less and electric driven complete with automatic lubrication, air intake filter, oil filters, after coolers, water/oil separators, discharge valves, non-return valves, automatic moisture trap and other associated accessories. The compressor shall have microprocessor based state of the art control.

The motor of the compressors shall be continuous duty and capable of being started by means of direct online starter. The insulation of motor winding shall be class-F with temperature rise limited to class B and designed to operate at 415V ± 10%, 50Hz ± 5%.

The compressor shall be delivered as package units on common frame with appropriate sizes AC squirrel cage motor and enclosed in suitable enclosures. Suitable anti-vibration pads shall be provided in the compressor foundation. Adequate protection shall be provided against starting of the compressor in loaded condition.

The water/ oil separator shall be equipped with an automatic solenoid operated drain valve to achieve automatic draining during standstill. The compressor stages shall be equipped with discharge valves, which shall close time delayed after start to avoid compressor start against full pressure.

13.6.2 Valves, Piping and Instrumentation

All embedded and exposed air piping shall be seamless stainless steel of minimum schedule 40. Pipe size up to 25mm shall be minimum schedule 80.

The valves in the air lines shall preferably be full bore ball type and the material for the seat and ball shall be stainless steel.

The valve shall be selected to have minimum leakage, reliable and ease of maintenance. Pressure gauges shall also be provided at the service air outlet line for measuring pressure at the remote/highest points.

The total pressure drop inclusive of the pressure drop in valves and other fitting should not exceed 0.3 bar at remote location.

Total leakage losses in the compressed air systems shall not exceed 3% of the total capacity of the respective compressor.

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Instrumentation such as thermometer, temperature sensors, pressure transmitter, moisture sensors, pressure gauges and pressure switches shall be provided for indication, alarm, monitoring and control.

The Contractor shall co-ordinate with the turbine, governor, generator and main inlet valve manufacturer (s) to decide about the layout of the piping system.

13.6.3 Air Receivers

The pressure tank shall be constructed from plate steel in accordance with part UW of the ASME Code for Unfired Pressure Vessels, Section VIII.

The tank shall be painted on the inside and on the outside as per approved painting system. Thickness of inside painting shall be such that these do not flake off during operation. Prior to shipping, all threaded openings shall be closed with standard pipe plugs. Flanged openings shall be protected with blind flanges with gaskets bolted in position.

Each air receiver tank shall be equipped with pressure gauge along with required numbers of electrical contacts, 2 pressure safety relief valve, drain valve, 2 inlet sockets with valves, 2 outlet sockets with valves and a pressure transmitter etc.

The safety relief valve shall be set to open on 110 % of the maximum working pressure of the system.

An automatic condensate drainage system shall be provided on the discharge separator to automatically drain condensate. It shall provide automatic drain of the system.

Each air receiver shall be equipped with a manhole to allow visual inspection. The plate thickness shall not be less than 8 mm for shell and 10mm for dish end.

13.6.4 Air Dryers

Compressed air system shall be provided with two regenerative type air dryers to dry the humid air. Normally one air dryer shall be used and shall have sufficient capacity to dry the air of both the compressors. The second air dryer shall be kept in standby mode for operation as and when required.

13.6.5 Control and Monitoring

The systems shall be controlled and monitored at three levels:

i) By respective local control cubicles for individual drive,

ii) Local Control Board for common services,

iii) Computerized control and monitoring (SCADA) system through Local Control Board for common services.

The Contractor shall make provision of contacts and/or ports in local control cubicles and centralized control panel for interfacing with SCADA system for control and monitoring.

In particular, the monitored parameters shall include:

i) Pressure thresholds,

ii) Number of starts ups and shut downs,

iii) No load operation timing at start up,

iv) Air receiver pressure values,

The compressed air systems shall be equipped with following instruments and protection systems, in addition to the visual indicators, thermometers, pressure gauges, pressure relief valves etc.:

i) Pressure switch triggering start-up of the normal air compressor,

ii) Pressure switch triggering start-up of the back-up air compressor,

iii) Pressure switch triggering air compressor shutdown,

iv) Pressure switch to detect low pressure in the compressed air pressure tanks for giving alarm,

v) Automatic shutdown if the discharge air temperature exceeds a predetermined, adjustable value.

However, the list is indicative only and scope shall be as per approved drawings/bill of materials during detailed engineering.

13.7 Inspection & Tests

13.7.1 Shop Tests

The motors, compressors, air receivers, valves and pipes etc. shall be routine tested as per relevant IEC/IS and international code for pressure vessels. The contractor is required to submit routine test certificates of the equipment. Copies of the type test certificates in respect of the similar equipment supplied in the past for hydro projects would also need to be supplied.

13.7.2 Field Tests

After installation, both compressed air systems shall be field tested for operational tests as per the intended requirements and leakage tested. Total compressed air system shall be pressure tested at 1.5 times of the design pressure. If the system shall be tested in sections, the same applies for each section.

All necessary materials and labour for performing the entire required test shall be provided by the contractor.

The contractor shall prepare and hand over to the Employer details of all test results in a report in a mutually agreed format.

13.7.3 Installation & Commissioning

The contractor shall furnish all labour, supervision, tools, supplies, bracing, spiders, shims and supports and all other provisions or materials necessary to assemble, erect, install, test and commission the equipment in a thorough workman like manner following the best modern practices. The equipment and all its components shall be placed with great care and accuracy and shall be aligned correctly to provide an installation consistent with the close tolerances used in the erection of modern equipment.

The proper elevations and centerlines to which equipment is to be set shall be established by the contractor.

All installation of compressors, air receivers and piping etc., of LP compressed air system shall be done by skilled workers in a workmanlike manner. Pipe fixtures shall be spaced according to accepted standards and provision made for thermal expansion and contraction of piping. Before installation all system components shall be checked for cleanliness.

13.8 Quality Control and Assurance

The Contractor shall submit detailed Quality Assurance Plan and Inspection Schedule for Employer's review and approval in accordance to clause 12 of General Technical Specification

13.9 Drawings, Documents and Design Calculations

13.9.1 Design Memorandum

The Contractor shall submit to Employer a design memorandum prepared in accordance to clause 2.5 "Design Memorandum" of General Technical Specifications.

13.9.2 Drawings and Documents

The Contractor shall submit all the drawings and documents in accordance with requirements stipulated in clause 2.6 "Drawings & Documents to be supplied by Bidder" of General Technical Specifications.

13.9.3 Design Calculation

The Contractor shall submit the design calculation in accordance to clause 2.6.4 "Design Calculations" of General Technical Specifications. Calculation for selecting the compressor capacity and motor rating,

Size and thickness selection of air receivers for compressed air systems,

Pipe size selection and pressure drop calculation.

The Contractor shall also provide other calculations as required by the Employer for his approval of the Contractor's design.

13.10 Delivery, Installation and Commissioning

The Contractor shall follow the general requirement of Delivery, Installation and commissioning as per relevant clauses in General Technical Specifications.

13.11 Schedule of Requirement

The scope of supplies and services shall be as per various clauses of the technical specifications and supplier shall be responsible to ensure completeness of supplies and services even if these are not fully covered under this clause.

Any item of supply not explicitly listed but otherwise implied by the contents of the specification or essential for smooth operation of the equipment shall be construed as forming part of the supply and no additional charges shall be payable for the same.

The broad schedule of requirements is given in clause 14.1.1 "Scope of Work".

13.12 Spare Parts

Recommended spare parts shall be supplied in accordance to clause 3 "Spare Parts and Tools" of General Technical Specifications. Specified spare parts to be supplied under this Chapter are as follows.

Sl. No	Description	Unit	Quantity
1	Air dryer complete assembly	no.	1
2	Safety valves	no. of each type	1
3	Pressure gauge, pressure switch and pressure transducer	no. of each type	1
4	Temperature gauge and temperature switch	no. of each type	1
5	Oil and air filter	nos. of each type	2
6	Automatic moisture trap	nos. of each type	2
7	Solenoid and directional valve	no. of each type	1
8	Standard gasket/ O- ring/packing kit for compressor	nos.	4
9	Valves DN15 and above	nos. of each type	2
10	Belts	nos. of each type	2

Besides above, the Contractor shall recommend any additional spare parts, which in his opinion are necessary for satisfactory operation of the system. However, the procurement of these recommended spares shall be at the discretion of the purchaser. The additional recommended spare parts shall be indicated in the Data Sheets of Volume-6.

13.13 Guaranteed & Other Technical Particulars

The Contractor shall follow the Guaranteed & Other Technical Particular requirements specified separately in Technical Data Sheets.

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13.14 Tools and Instruments

The Contractor shall supply all necessary tools and Instruments etc. for installation, repair and maintenance in accordance to clause 3.2 “Tools and Instruments” of General Technical Specifications.

13.14.1 Special Tools

The Contractor shall list and supply all special tools. List of such tools including their make and detailed specification, shall be submitted for acceptance by the employer.

13.15 Deviations from Specifications

All deviations from these specifications shall be separately listed in the requisite Performa of the bid document, in the absence of which, it will be presumed that the provisions of the specifications are fully complied with by the bidder. However, the deviations, which are better than the specifications shall be considered by the purchaser.

13.16 Completeness of Contract

Any fittings, accessories or apparatus required for successful commissioning though may not have been specifically mentioned in the specification but are usually necessary for the completeness of the works shall be deemed to be included in the specification and shall be supplied by the bidder without any extra cost to the purchaser.

CHAPTER 14: DRAINAGE & DEWATERING SYSTEM

14.1 Scope of Work

Scope of work under this section covers the provision of labour, tools, plants, materials and performance of work necessary for the design, manufacture, quality assurance, quality control, shop assembly, shop testing, delivery at site, site storage and preservation, insurance, installation, commissioning, performance testing, acceptance testing, handing over to Employer and guarantee for three years of drainage and dewatering system, as per the specifications hereunder, complete with all auxiliaries, accessories, spare parts and warranting a trouble free safe operation of the installation. The Systems shall be suitable for Ambient, Seismic, Altitude and other site conditions as detailed in General Technical Specifications.

The scope of work shall be a comprehensive functional system covering all supply and services including but not be limited to following:

14.1.1 Submersible Pumps and Accessories

i) Three (3) (2W + 1S) Submersible pumps with starter panel, submersible cables and associated accessories for automatic operation of powerhouse drainage system.

ii) Three (3) (2W + 1S) Submersible pumps with starter panel, submersible cables and associated accessories of both the cooling water pits sumps.

iii) Three (3) (2W + 1S) Submersible pumps with starter panel, submersible cables and associated accessories for automatic operation of oil water sump at transformer cum GIS cavern.

iv) Necessary isolation valves, piping, regulating orifice, air scouring arrangement, floor/sump covering grating/chequered plate, all type of consumables and other materials,

v) Necessary heavy duty chequered plate covers on all drainage sumps.

vi) Necessary pressure gauges, pressure switches, level transmitter, level switches etc.

vii) One (1) set of electric monorail hoist arrangement of 2T capacity along with associated accessories for handling of all powerhouse drainage and flood protection, as per approved drawing during detailed engineering.

viii) All power cables, control cables and special cables, cable racks, cable glands, lugs, terminals, connectors etc. for cabling between equipment and devices covered in this chapter,

ix) Coordination and provision of necessary contacts and/or ports for integration with plant SCADA system.

x) Spare parts in accordance to clause 13.12 “Spare Parts” of this section,

xi) Tools and instruments in accordance to clause 13.14 “Tools and Instruments” of this section.

Any other item(s) not mentioned specifically but necessary for the satisfactory completion of scope of work defined above, as per accepted standard(s)/best international practices.

14.1.2 Specific Parameters and Layout Conditions

The tentative location of sumps shall be as per the powerhouse layout drawing.

All of the drainage sumps shall be provided with heavy duty chequered plates cover.

14.2 Specific Design & Layout Conditions

14.2.1 Power House Complex Drainage System

A drainage gutter spanning the length of the powerhouse shall be provided for collection of seepage and leakage from all the units. The powerhouse drainage gutter shall terminate in the Main drainage sump of Powerhouse.

The powerhouse drainage system shall take care of any sudden increase in powerhouse leakage to avoid any potentially disastrous effect. The drainage system shall maintain the electrical installations above water in design basis accident situation. All the seepage and leakage water from different floors of the powerhouse shall be gravity drained to tail race channel. The areas where gravity drainage is not feasible, the leakage / seepage shall be channelized into drainage sump via drainage gutter. Discharge resulting from firefighting operation in transformer cavern shall accumulate in the 'Oil water sump' located in the transformer floor in transformer cum GIS cavern.

The drainage sumps shall have continuous duty submersible pumps with float switches for auto starting and stopping of pumps. All drainage and flood protection piping including embedded piping shall be provided with adequate air scouring arrangement and shall be properly supported. The size of the outlet pipes for powerhouse drainage system shall be sufficient to accommodate one additional pump of same capacity and shall have tapping for connection of one additional pump in future. One spare drainage pipe of DN 300 with valves and blank flanges shall be laid for discharge of water from drainage to outside the powerhouse.

Suitable provision shall be made to clean the drainage gutter and sump once the station is watered up and commissioned. As the gutter and sump shall also act as collection point for any silt or sand which may enter the powerhouse either through leakage or through floor waste, adequate arrangement shall be provided for removal of the same.

In addition to main powerhouse drainage, provision shall also be made to cover the following areas with suitable drainage system:

i) Transformer cum GIS cavern,

ii) Cooling water sumps – 1&2.

14.2.1.1 Main Drainage Sump in Power House Cavern

The powerhouse drainage system shall consist of a main drainage sump for collection of seepage & leakage from all the units including water from other areas of powerhouse.

The sump shall be provided with two (2) nos. of pumps each having capacity of 6 cubic meter/min of discharge. The water collected in sump shall be pumped out beyond TRC gate of unit # 4. Alternate provision shall also be made to pump out the water beyond gate at Main Access Tunnel of Powerhouse.

14.2.1.2 Elevator Pits in Power House Cavern

Elevator pits shall have adequate size gravity drain pipe emptying into the drainage sump.

14.2.1.3 Drainage of Cooling Water Pits

Each of the cooling water pits shall be provided with a submersible drainage pump to keep the pit dry for maintenance of heat exchanger. The water from the sump shall be pumped to beyond tail race tunnel gate of unit#4.

14.2.1.4 Transformer Oil Water Sump and Transformer Vaults

One large sump shall be provided in the transformer cavern floor to store single transformer oil charge plus forty (40) minutes of deluge flow. This shall allow retention of any oil released during a fire for subsequent removal, for which suitable arrangement shall be provided by the Contractor. The transformer oil water sump shall have proper oil retrieval arrangement. The sump shall contain two submersible pumps of 3cubic meter/min. capacity. The water from the sump shall be pumped beyond TRT gate.

The transformer vaults shall incorporate a curbed collection chamber sized to contain a quantity in excess of the oil volume in a transformer. Fire deluge water shall collect in a trench at the bottom of the chamber after passing through a crushed stone quenching bed. From the trench, deluge flows shall be led through water trapped elbows into transformer oil water sump.

14.2.2 Design Considerations

The project is situated in Himalayan region where the silt content during high flow period is excessive and peaks abnormally. Submersible pumps may be expected to handle water with high silt concentration. Reliability of the pumps in high silt laden water is of critical importance as bottom of sump pits shall have substantial silt deposition.

The Contractor shall critically study the silt data and chemical analysis of water and take the same into account in designing the Drainage & Flood Protection system susceptible to abrasive effect of silt, making all such specific provisions and measures including selection of materials, surface coating, corrosion protection/ painting which will help to resist silt erosion/abrasion and enable easy and quick maintenance/replacement of worn out components.

14.2.2.1 Maximum Water Level for Design Basis Accident Situation

During design basis accident situation as mentioned hereafter, the flood water shall accumulate in the MIV floor in accident situation. However, under no circumstances, the water level shall be allowed to go above that elevation which is designed as 'Maximum water level' for design basis accident situation.

14.3 Standards

The system and equipment shall be designed, built, tested and installed to the latest revisions of the following applicable standard. In the event of other standards being applicable they will be compared for specific requirement and specifically approved during detailed engineering for the purpose:

Sl. No	Standard	Description
1	IS 4721	Code of Practice for Drainage and Dewatering of Surface/Underground Hydroelectric Power Station
2	IS: 325	Specification of Induction motors
3	IS: 1239	Specification of pipes
4	IS: 3589	Specification of pipes above 150mm
5	IS: 2062	Steel for general structural purposes
6	IS: 13947	Contactor and motor starter

14.4 Rating and Functional Characteristics

14.4.1 Drainage System

The total pumping capacity and drainage sumps of the drainage system must be designed to handle the seepage, leakage for all the units and the largest fire protection deluge flow in the powerhouse.

The pumps shall be submersible type having discharging capacities as per the details given below. The pumping head shall have minimum 10% safety margin with respect to the static head and head loss in the circuit. The ratings mentioned below are tentative and only for information to the Contractor. The Contractor shall do necessary calculation proving the adequacy of the selected pump- motor rating. In any case, minimum pump discharge shall be as per below. The pumps shall be suitable for continuous operation, capable of pumping water with heavy silt, directly driven by electric motor rotational speed of which shall preferably be not more than 1500 rpm subject to hydraulic flow conditions and operating zones of the pumps, higher speed shall be acceptable under technical/ manufacturing compulsions only.

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Sl. No.	Description	Nos. of Pumps	Rating of each pump
			LPM (min.)
1	Pumps for power house main drainage sump (S # 1)	3	As per Design
2	Pumps for Cooling water pit drainage sump (S # 2 & 3)	3	As per Design
3	Pumps for oil water sump (S# 4)	3	As per Design

The drainage and flood protection system shall entirely operate by its own automatic control equipment. All control equipment of the drainage and flood protection system shall be located above the maximum water level.

14.5 Performance Criteria & Guarantee

The drainage system along with all auxiliaries and accessories shall be capable of performing intended duties under specified conditions and as specified in Data Sheets of Volume-6. The Contractor shall guarantee the reliability and performance of the individual equipment as well as of the complete system.

14.6 Design and Construction

14.6.1 Pumps

The drainage pumps shall be of vertical, double sealed, submersible type with motors of continuous duty capable of pumping raw, unscreened, heavily silt laden water. The submersible pumps shall be of a proven design suitable for solids handling. All pumps of similar capacity shall be interchangeable.

The material for pump impeller shall preferably be high grade duplex stainless steel (AISI 329 or better). The pump impeller shall have high efficiency multi thick vane with excellent abrasion and corrosion resistant properties. The wall thickness of pump casing shall be suitable for heavy duty. The material for shaft, hardware and fasteners shall be stainless steel (AISI 420 or better). The pump impeller shall be properly balanced along with other rotating parts on proper balancing equipment to prevent vibration. The casing of the pump shall be of ductile iron or improved cast iron.

Two numbers heavy duty mechanical seal for submersible pumps shall be provided. The material of primary and secondary seal shall preferably be heavy duty Silicon Carbide (SiC) or Tungsten Cemented Carbide (WCCR).In addition to the dynamic designed capabilities of the pumps, pump-motor including mechanical seals, motor sealing, cable glands, flange joints etc. shall also be designed to sustain maximum water submergence pressure for giving trouble free performance (to be finalized during detailed engineering). The pump-motor bearings shall have minimum life expectancy of 70, 000 hours.

Pumps shall be provided complete with continuous duty electric motors with class H/F insulation (temperature rise limited to class B), starter for auto operation, power cable (joint less cable from pump to starter panel), discharge piping and hardware, anchor bolts and other mounting materials. The pumps shall be suitable for 415 V ± 10%, 50 Hz ± 5% with contacts for remote operation / indication.

Pump motors shall be suitable for minimum 15 starts per hour and shall have minimum service factor of 1.15.

Pressure switch/ Flow switches with suitable nos. of contacts for remote indication and alarm shall be provided for each pump. Shut-off valves and check valves shall be provided for each pump to allow disconnection and switching of each pump without emptying pipes. All common delivery pipe shall necessarily be provided with one gate valve at outlet side so as to enable to close the same under emergency when tail water level is very high. Each pump shall be

provided with pressure gauge, pressure switches/flow switches with isolation valve in the discharge side. Power house drainage sump shall also be provided with level transmitter for remote continuous sump water level indication.

Submersible pumps shall be installed in wet sump/pit on a guide rail to allow for removal and installation of pumps without entering the wet well. The pumps shall be provided with auto-setter coupling, discharge base, lifting lug, guide support, guide rail and chain. The material for guide support, guide rail, bolts, hardware and chain shall be stainless steel.

14.6.2 Valves, Piping and Floor Drains

All required pipes, valves, flanges, fittings, supports, fasteners, and related material shall be supplied as part of this contract. All embedded and exposed piping shall be carbon steel of minimum schedule 40. Pipe size upto DN 25 shall be of minimum schedule 80. All gravity drain pipes shall be of minimum schedule 20. The piping and valves shall be in accordance with "Piping, Fittings, Valves, and Heat Exchangers" of General Technical Specification (GTS).

The contractor shall do necessary coordination and shall make detailed layout drawings for routing of the pipes etc. and submit the same for approval of the Employer during detailed engineering. Silent type check valves shall be used in pump discharge lines.

The velocity in the pipe shall normally not to exceed 3.0m/s.

All required pipes, valves, flanges, fittings, supports, fasteners, and related material shall be supplied as part of this contract. Valve body of all type of valves shall be preferably of cast steel except smaller valves (50 mm and lower) for which material shall be stainless steel.

14.6.3 Insulation for Piping

In case of anticipated condensation of any part of the exposed pipes, the same shall be insulated against condensation with approved type insulation/lagging with vapour proof cover, if required.

14.6.4 Control and Monitoring

The drainage and Flood Protection system shall also be controlled and monitored by the **SCADA** system.

14.6.4.1 Control

The pumps shall be controlled and monitored at three levels:

i) By respective local control cubicles,

ii) Local Control Board for common services

iii) Computerized control and monitoring (SCADA) system through Local Control Board for common services.

Facility for selection of control either from Local Control Cubicle or Local Control Board or plant SCADA system shall be provided in the Local Equipment Panel or Local Control Board.

The Contractor shall make provision of contacts and/ or ports in local control cubicles for interfacing with SCADA system for control and monitoring. The Contractor shall provide and install all the sensors and operating devices necessary to fulfil the functional requirement of the specification for control system.

All pumps shall be automatically controlled based on the sump level sensed by adequate instrumentation. However, control philosophy shall also have following control provisions:

i) Automatic start and stop of pumps on the basis of low and high water level in the sump,

ii) Running time control with change of sequence to equalize running time,

iii) Automatic starts of next lower running time pump in case of hydraulic or electrical fault in pump,

Following local controls, but not limited to, shall be provided for each drainage pump:

i) Manual/ Automatic switch for manual/automatic operation of each pump,

ii) Remote/ local selector switch for each pump,

iii) Start/stop push buttons for each pump,

iv) Lamp test push buttons.

14.6.4.2 Indication and Alarms

The Contractor shall supply suitable instruments and gauges for achieving desired control logic. Indicating instruments as required shall be installed on local control panel and indications may be replicated in Local Control Board/ control room for common services.

Following indications and alarms, but not limited to, shall be provided for each drainage water pump:

i) Pump running/stop/trip for each pump,

ii) "No flow" for each pump,

iii) Very high and very low water level (sump) alarms,

iv) Other indications, if any.

14.6.4.3 Protection

The motor for each pumping unit shall be provided with at least the following device:

i) Overload protection,

ii) Under voltage protection,

iii) Single phasing protection,

14.7 Inspection and Tests

14.7.1 Shop Tests

The pump, pipes and valves shall be routine tested as per relevant IEC/IS at the works of contractor. The contractor is required to submit type test certificates and routine test reports of equipment for approval by Owner before dispatch of equipment.

14.7.2 Field Tests

After installation of all equipment the complete system shall be leakage tested as per field test in general technical specifications as per IEC / IS.

The contractor shall furnish a complete outline of proposed method and procedures to be followed for field testing including a list of equipment and instruments to be used for Owner's review well in advance before the scheduled testing.

The contractor shall furnish a complete report of the field tests of the equipment.

After installation and prior putting the equipment in operation at least following site tests shall be carried out;

i) The complete system along with pumps shall be hydrostatically tested for leakage at requisite pressure. The system shall be maintaining the requisite pressure for 24 hours without showing any sign of pressure loss and leakage. If the system is tested in sections, it applies for each section,

ii) Pump output test,

iii) Opening and closing of all valves,

iv) Other tests as deemed necessary by the engineer.

14.7.3 Installation and Commissioning

The contractor shall furnish all labour, supervision, tools, supplies, bracing, spiders, shims and supports and all other provisions or materials necessary to assemble, erect, install, test and commission the equipment in a thorough workman like manner following the best modern practices.

The equipment and all its components shall be placed with great care and accuracy and shall be aligned correctly to provide an installation consistent with the close tolerances used in the erection of modern equipment.

Pipe fixture shall be spaced according to accepted standards and provisions made for thermal expansion and contraction of piping. Before installation, all system components shall be checked for cleanness and after installation the systems shall be effectively flushed out with clean water and filled up for testing.

14.7.4 Test Reports

Shortly after completion of the field acceptance tests the Contractor shall prepare and forward draft copies of the field acceptance test report to the Employer for review. After review and acceptance, the contractor shall furnish six (6) copies of the final report.

14.8 Quality Control and Assurance

The Contractor shall submit detailed Quality Assurance Plan and Inspection Schedule for Employer's review and approval in accordance to clause 12 of General Technical Specification

14.9 Drawings, Documents and Design Calculations

14.9.1 Design Memorandum

The Contractor shall submit to Employer a design memorandum prepared in accordance to clause 2.5 "Design Memorandum" of General Technical Specifications.

14.9.2 Drawings and Documents

The Contractor shall submit all the drawings and documents in accordance with requirements stipulated in clause 2.6 "Drawings & Documents to be supplied by Bidder" of General Technical Specifications.

14.9.3 Design calculation

The Contractor shall submit the design calculation in accordance to clause 2.6.4 "Design Calculations" of General Technical Specifications covering at least the following, for review/ acceptance.

i) Calculation for selection of pump head, pump flow and pump motor rating for drainage system

ii) Any other calculation required during detailed engineering,

14.10 Delivery, Installation and Commissioning

The Contractor shall follow the general requirement of Delivery, Installation and commissioning as per relevant clauses in General Technical Specifications.

14.11 Schedule of Requirement

The scope of supplies and services shall be as per various clauses of the technical specifications and supplier shall be responsible to ensure completeness of supplies and services even if these are not fully covered under this clause.

Any item of supply not explicitly listed but otherwise implied by the contents of the specification or essential for smooth operation of the equipment shall be construed as forming part of the supply and no additional charges shall be payable for the same.

The broad schedule of requirements is given in clause 13.1.1 "Scope of Work".

14.12 Spare Parts

Recommended spare parts shall be supplied in accordance to clause 3 "Spare Parts and Tools" of General Technical Specifications. Specified spare parts to be supplied under this Chapter are as follows.

Sl No	Description	Unit	Quantity
1	**Submersible pumps for powerhouse drainage system**		
1.1	Complete submersible pump–motor set	no.	1
1.2	Complete set of pump shaft seal including mechanical seal	nos. of each type	2
1.3	Complete set of wearing rings, O-rings and gaskets	nos.	2
1.4	Submersible cable (length to be mentioned by the Contractor)	length	1
2	**Submersible pump for oil-water sump**		
2.1	Complete submersible pump–motor set	no.	1
2.2	Complete set of pump shaft seal including mechanical seal	nos. of each type	2
2.3	Complete set of wearing rings, O-rings and gaskets	nos. of each type	2
2.4	Submersible cable (length to be mentioned by the Contractor)	nos. of each type	1
3	**Submersible pump for Drainage of cooling water pit**		
3.1	Complete submersible pump–motor set	no.	1
3.2	Complete set of pump shaft seal including mechanical seal	nos. of each type	2
3.3	Complete set of wearing rings, O-rings and gaskets	nos.	2
3.4	Submersible cable (length to be mentioned by the Contractor)	length	1
4	Pressure switches	nos. of each type	1
5	Valves of each type 80mm and above	no.	1
6	Pressure gauges	nos. of each type	1
7	Level switches	nos. of each type	1
8	Level transducer of each type	no.	1

Besides above, the Contractor shall recommend any additional spare parts, which in his opinion are necessary for satisfactory operation of the system. However, the procurement of these recommended spares shall be at the discretion of the purchaser. The additional recommended spare parts shall be indicated in the Data Sheets of Volume-6.

14.13 Guaranteed & other Technical Particulars

The Contractor shall follow the Guaranteed & Other Technical Particular requirements as specified in Data Sheets of Volume-6.

14.14 Tools and Instruments

The Contractor shall supply all necessary tools and Instruments etc. for installation, repair and maintenance in accordance to clause 3.2 of General Technical Specification.

14.14.1 Special Tools

The Contractor shall list and supply all special tools. List of such tools including their make and detailed specification, shall be submitted for acceptance by the Employer.

14.15 Deviations from Specifications

All deviations from these specifications shall be separately listed in the requisite Performa of the bid document, in the absence of which, it will be presumed that the provisions of the

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specifications are fully complied with by the bidder. However, the deviations, which are better than the specifications shall be considered by the purchaser.

14.16 Completeness of Contract

Any fittings, accessories or apparatus required for successful commissioning though may not have been specifically mentioned in the specification but are usually necessary for the completeness of the works shall be deemed to be included in the specification and shall be supplied by the bidder without any extra cost to the purchaser.

CHAPTER-15: DC SYSTEM

15.1 Scope of Work

This specification covers the design, engineering, manufacture, inspection, testing at BIDDER's and/or his sub-vendor's works, packing, transportation, delivery to site, including transit insurance, erection, testing, start-up, commissioning and performance testing of all the equipment's and accessories required for the complete 220V DC System for control, protection, interlock, annunciation & communications of the complete power plant and GIS /switchyard.

15.2 Following list of items shall be provided for the project:

i) 2x100% rated 220V Lead Acid Plante battery with associated 2x100% (float + float cum boost charger) and Two (2) no. DC switchboard with bus coupler arrangement shall be provided for catering the power plant and GIS / pot head yard loads. Refer SLD.

ii) An eye wash facility with distilled water shall be provided in the battery room.

iii) Scheme for earth fault detection shall be provided for each DC bus and feeders.

iv) Over voltage and Under voltage protection shall be implemented and integrated with SCADA system for monitoring and control.

v) All required DC cables and other accessories shall be in BIDDER's scope.

vi) Hydrogen gas sensor shall be provided in the battery room, and it shall be further communicated with SCADA.

15.3 Codes and Standards

The design, material, construction, manufacture, inspection, testing and performance of equipment shall comply with all currently applicable standards, codes of practice, regulations and safety codes in the locality where the equipment will be supplied & installed. Nothing in this specification shall be construed to relieve the CONTRACTOR of this responsibility.

The codes and standards mentioned in the various specifications and requirements specified in the enquiry document shall be latest as on the day of award of contract of the works unless otherwise specified. Contractor shall be responsible to inform to the Consultant/ Owner in case of any revisions/re-affirm/amendment in the relevant codes and standards after the date of award of contract within 30 days of the issue of such revision/re-affirm/amendment of the code/ standard. Consultant/ Owner may approve use of the earlier code/ standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed.

In case of conflict between the applicable standards and this specification, the more stringent of the two shall govern.

15.4 Design Criteria

15.4.1 Lead Acid Plante Battery

i) The Lead Acid Plante batteries shall allow recombining of generated oxygen internally. The battery shall be completely explosion resistant.

ii) Battery Cell nominal voltage shall be 2.0 V per cell and Cell voltage required for float charging shall be taken as 2.25 Volts / cell as recommended by Battery – OEM.

iii) The battery bank shall be sized for a discharge rate with end cell voltage per cell as 1.85V.

iv) Battery for all systems shall be sized in accordance with IEEE 485-1997.

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v) A design margin of 20% shall be considered.

The DC Batteries shall be suitable for a long life under continuous float operations and occasional discharges. The 220V DC systems should be unearthed. Battery sets shall be capable of operating at a peak ambient temperature of 50 Deg.C. The offered battery shall be compact and shall require no maintenance. All safety equipment required for installation shall be provided by the manufacturer.

The D.C. Battery shall be operated without an intentional ground. For indicating the incidence and degree of a ground fault on the D.C. control circuitry, the midpoint of the battery shall be earthed through an ammeter (center Zero) of high resistance.

15.4.2 The battery located at powerhouse shall be sized to cater the station loads as follows:

i) Continuous Load (For 10 hours duration)
   a) Indicating lamps on switchgears and control panels
   b) Auxiliary relays
   c) Water level indicators
   d) Panel DC loads

ii) Emergency Load (For 2 hours duration)
   a) Emergency lighting
   b) PLC & Instrumentation Loads

iii) Momentary Load (For duration up to 1 minute)
   a) Tripping / closing loads of breakers
   b) In-rush current of excitation system

An aging factor of 1.0 (for Plante Battery) shall be considered in sizing the battery as per IEEE 485.

The temperature correction factor as given in IS. For this purpose, electrolyte temperature shall be considered as 5ºC above the ambient temperature.

The BIDDER shall furnish battery-sizing calculations during detailed engineering for PURCHASER's / ENGINEER's approval

15.5 Battery Charger

i) The float and boost battery charger shall be static type composed of silicon-controlled rectifiers (SCRs) connected in three phase full wave bridge circuit along with electronic controllers.

ii) The rectifier transformers for float and boost chargers shall be indoor dry type, double wound with delta-delta/suitable vector connections.

iii) It shall be provided with an adequately rated isolation transformer and filters on input to minimise harmonics and to keep ripple factor within acceptable limits.

iv) Battery Charger (220V) shall be suitable to operate at 415V AC, three phase, 50HZ supply. The chargers should be capable to deliver the full rated load at specified voltage at output terminals. This voltage is maintained for AC input variation of +10%, -15% and load variation from 0-100% full load.

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v) The battery charger shall be suitable for operating under input voltage and frequency variations as given below:

a) Voltage: 415 (-15% to + 10%)

b) Frequency: ± 5%

vi) Float cum boost charger shall be rated to cater to the following loads in float mode:

a) Trickle charging current of the battery.

b) Continuous load (10 hours) for 220V DC System.

c) Largest DC motor running current

d) 25 % spare capacity over above loads.

e) The float voltage output of the float charger shall be automatically adjusted depending upon the ambient temperature such that the batteries remain floating throughout the range of variation of temperature.

vii) In boost mode, the charger shall be rated such that the battery can be fully charged from fully discharged condition within 8 hours for normal charging.

viii) The SMPS based charger shall have N+1 module configuration.

ix) All components shall be rated for the electrical system characteristics, voltage and frequency variations as stated on the data sheets(s).

x) Battery Charger system shall be static type composed of Switch Mode Power Supply (SMPS) modules and suitable for use with any selected type batteries (as specified in the datasheet).

xi) All components shall be rated for charging the battery set(s) in both float/boost modes plus full load requirements at continuous operation for the specified life of the system in the specified design conditions. All components shall be capable of withstanding the thermal and dynamic stresses resulting from internal and external short-circuits and circuit switching operations, etc. Damage arising from component failure should be confined to the component concerned.

xii) Protection shall be provided against supply system switching transients, input surges and short circuits. The load limiter characteristic will be such that any sustained overload or short circuit in DC system will neither damage the charger nor will it cause blowing of any of the charger fuses. The charger will not trip on overload or external short circuit. After clearance of fault, the charger voltage will build up automatically when working in automatic mode.

xiii) If the equipment's supplies require forced air cooling, all fans shall be equipped with monitoring facilities to trigger an alarm in the event of fan failure.

xiv) The design of the charger unit shall be such that replacement of an SMPS module can easily be carried out and shall be hot swappable / hot pluggable.

xv) The charger unit efficiency shall be greater than 90% and power factor shall be minimum 0.9 at all loads from 50-100%.

xvi) The maximum allowable RMS ripple voltage, with battery disconnected, shall be equal to or less than 0.5% rms of the nominal output voltage.

xvii) The SMPS Module's input current harmonics (THDi) shall not be more than 5%.

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xviii) The SMPS module shall have Soft Start feature (upto 10 Seconds)

xix) The controller shall have facility to change set points, prepare or examine an event or alarm log, etc. access to charger settings and configuration shall be password-protected.

xx) It shall be possible to connect charger through RJ45 to DCS or SCADA system for selected analogue and digital data to be made available to a higher-level controller. Communication shall be by MODBUS TCPIP. If there is any converter requirement to communicate in that protocol, this must be supplied by the vendor, and it is the responsibility of vendor to communicate the required parameters to DCS/SCADA.

15.6 Float Charging Mode

i) The D.C. output voltage during float charging shall be stabilised within + 1% of the set DC bus voltage for AC input voltage variation of ±10%, frequency variation of ± 5% and DC load variation from 0 - 100%. The voltage regulation shall be achieved by a constant voltage regulator having fast response SCR control or with high frequency SMPS with intelligent control. The ripple content shall be within 1% of D.C. output nominal voltage with battery disconnected. Also in any mode of operation, the maximum current harmonics in the charger input, both in float and boost mode operation shall not exceed 5% and input power factor shall be better than 0.85.

ii) The setting of the output D.C. bus voltage shall be adjustable between + 10% of nominal rated voltage.

iii) There shall be provision for manual control if auto mode fails.

iv) The load (current) limiting feature of the float charger should be designed to take care of the loads connected. The chargers shall have load limiters which shall cause, when the voltage control is in automatic mode, a gradual lowering of the output voltage when the DC load current exceeds the load limiter setting of the Charger. The load limiter characteristic shall be such that any sustained overload or short circuit in DC system shall neither damage the Charger nor shall it cause blowing of any of the charger fuses.

v) Line Surge Suppressers Shall be Provided.

15.7 Boost Charging Mode

For boost charging the discharged battery after a mains failure, the rectifier shall charge the battery at high rate limited to the maximum boost charging voltage.

In auto control, the DC output current shall be stabilised within +2%for AC input voltage & frequency variation of + 10% and + 5% respectively. There shall be provision for manual control if auto-mode fails.

The boost charge voltage and current settings shall be adjustable between 70 to 100% of maximum boost charge voltage and between 50 to 100% of maximum boost charging current. It shall have a provision for initial charging. Preferably AH input to the battery shall be measurable to facilitate accurate first charging.

During boost charging following emergency measures shall be provided:

i) If the AC mains supply fails, an arrangement shall be made to automatically connect the battery directly across the load.

ii) In case of Float cum boost charger and standby float charger scheme with one battery, If the standby float charger supplying D.C. load fails and tap cell diode arrangement, the load shall be fed from the point of connection at the tapping of the battery via

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adequately rated blocking diodes. Two blocking diodes in series shall be provided to take care of short circuit of any one diode.

iii) Battery shall feed the load through dropper diode which is provided at the output of the charger to prevent the high voltage charge damaging the loads. Dropper diode shall be bypassed otherwise through adequately rated DC Contactor.

The cable drops to be considered in DC system shall be 2% from the charger / battery to distribution board and 3% from board to any feeder in case of 220V DC system.

15.8 Constructional Features

15.8.1 Batteries

i) The battery offered shall be capable of high discharge performance and shall be suitable for indoor application.

ii) The batteries shall be complete with accessories and devices, including but not limited to the following:

a) **Battery racks**

b) **Porcelain insulators, rubber pads etc.**

c) **Set of lead coated inter-cell, inter-tier and interbank connectors as required for the complete installation.**

d) **Electrolyte for first filling +10% extra**

iii) One set of variable resistor load suitable for carrying out discharge tests at 10 hour discharge rate & suitable shunt for measuring current on all batteries shall be supplied. Alternatively, electronic controls for carrying out discharge test of the batteries at selectable rate can also be provided.

15.8.2 Battery chargers

i) Charger cubicles shall be sheet steel enclosed and shall be dust, weather and vermin proof. Sheet Steel used shall be cold rolled and at least 2.0mm thick and properly braced to prevent wobbling. The components shall be housed in a well-ventilated sheet metal cubicle complete with input and output terminals.

ii) All printed circuit cards shall be plug-in type, interlocked to prevent insertion in a wrong slot. Each card shall have LED indication on its front plate to indicate normal condition and readily marked test pins

iii) The layout of Charger components shall be such that their heat losses do not give rise to excessive temperature within the Charger panel surface. Location of the electronic modules will be such that temperature rise of the location, in no case, will exceed 10°C over ambient air temperature outside the Charger.

15.8.3 Components/Accessories

i) Three phase full wave, bridge rectifier circuit comprising silicon-controlled rectifiers and silicon diodes complete with resistor/capacitor network for surge protection. The SCRs shall be individually protected by fuses and fuse fail indication. The fuses shall be of fast acting semiconductor type.

ii) Double wound, dry type, three phase suitably rated mains transformer with fuse/MCB protection and with one set of power factor correction capacitors to maintain a power factor of 0.85 (lag) at both float and boost operation mode.

iii) Suitable rated series inductor to reduce the ripple contain in the output DC.

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iv) Suitable rated control transformers for electronic controller.

v) Electronic controller comprising of power supply card, soft start cum current limit card, auto trickle mode card with facility for setting trickle charge current and monitoring battery current, error amplifier cards and pulse generating cards for achieving the DC output voltage stabilisation of +1% and also for achieving current limiting feature. The electronic controller shall be provided with boost current stabilisation and boost charge current limiter. The electronic controller shall have protection features with indications for under-voltage, over-voltage, earth fault, set output voltage and phase failure or voltage unbalance.

vi) Adequately sized necessary built-in accessories shall be provided such that on failure of the controller in auto mode the voltage can be effectively controlled manually.

vii) Filter circuit comprising of smoothing choke and condensers complete with HRC fuse with trip indication for filter condenser circuit.

viii) One (1) Auto / Manual selector switch for selecting the mode of operation of the controller.

ix) One (1) front panel mounted potentiometer for set point adjustment of output voltage in auto /manual mode. In case of float cum boost charger, the potentiometer for set point adjustment of output voltage for auto and manual operation shall be sized to take care of maximum boost voltage.

x) One (1) set of MCCB / ACB for AC input with suitable ratings and with trip indication for each of the charger units

xi) One (1) AC contactor with suitably rated coil with three main contacts and 2 NO + 2 NC auxiliary contacts, suitably rated thermal overload relay and ON/OFF control switch.

xii) One (1) set of MCCB/ACB for the DC output and with trip indication.

xiii) One no. make before break type selector switch for charging mode.

xiv) DC contactor of suitable rating for disconnection of load during boost charging.

xv) One (1) battery under voltage relay to annunciate fully discharged condition of the battery.

xvi) Two (2) nos. blocking diodes in series to block back feed from battery to float charger.

xvii) One (1) cubicle space heater suitable for 240 V AC 50 Hz, single phase shall be provided.

xviii) One (1) 240 V AC LED lamp for cubicle internal lighting shall be provided.

xix) Two (2) - ON/OFF switches with MCB for space heater and internal lighting shall be provided.

xx) Tap cell – blocking diode/dropper diode.

xxi) A separate wall mounted isolation switch shall be provided for emergency battery isolation. It shall carry the rated current in both direction of current flow. It shall be enclosed in sheet steel enclosure of at least 2mm having IP 54 degree of protection. The isolation switch box shall be wall mounted type located in battery room.

xxii) Switch shall not trip on fault, only upstream battery charger MCCB/ACB shall be tripped. Switch ON/OFF status indicators shall be provided. Potential free contacts for remote indication of close/open status of the switch shall also be provided.



15.8.4 Battery Charger Monitoring System

i) Battery charger shall be provided with MMI unit to monitor & annunciate the charger parameters.

ii) There shall be a LCD display (4X20) in which all the parameters like faults; AC/DC voltage can be seen. The micro controller shall have fault history (events with Date & Time) logging & retrieval facility. Controller shall have one RS485 port facility to monitor all the parameters indicated below from remote location. Controller shall have facility to change the alarm set points at site (password protected).

iii) Following annunciation shall be provided as minimum:

a) Mains AC failure

b) Charger overload.

c) DC output breaker tripped

d) AC input breaker tripped

e) Battery fully discharged

f) Battery on boost

g) DC system earth fault

h) DC under voltage

i) DC Over voltage

j) Float/Boost charger rectifier fuse blown

k) Float/Boost charger filter condenser fuse blown.

l) Charger current limiter protection operated

m) Battery breaker tripped

n) Battery on boost.

o) Boost charge changeover alarm (When battery reaches min voltage limit , alarm to change it to Boost mode)

iv) Analog/digital meters shall be provided for each charger to read the following measurement parameters:

a) AC input voltage and current

b) Charger input current.

c) DC Output current of Float/Boost Charger

d) DC Output voltage of Float/Boost Charger

e) Load voltage and current

f) Battery voltage

g) Battery current

h) Charge/discharge currents of the battery

v) Following LED status indications shall be provided:

a) C Input R, Y, B ON

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b) Float Charger ON

c) Boost Charger ON

d) Battery ON

e) Equalizing charge ON

15.8.5 Power Electronic Components

i) Thyristors shall be of monocrystalline type silicon, capable of providing continuous output at specified voltages. It shall have high power efficiency.

ii) If many thyristor assemblies are connected in parallel, care shall be taken to ensure that each rectifier or thyristor operates within its rating and shares the load uniformly.

iii) Thyristor built in a multi-built assembly shall be provided with a short circuit protection to avoid complete shut-down of the equipment because of a fault on single unit. Suitable fuses shall be provided for such protection.

iv) Necessary spare capacity shall be built in the equipment to continuously supply full load even with one unit out of circuit.

v) Thyristor banks shall be natural air cooled

vi) Thyristors shall be protected against overvoltage due to chopping surges with the aid of snubbers (i.e. resistor-capacitor combination and Metal oxide variator).

15.9 D.C. Distribution Boards

i) DC switchboards shall be provided for the DC loads as specified above.

ii) The switchboard shall have two incomers and bus coupler. The switchboards shall be provided with suitable quantity and type of outgoing feeders for the auxiliaries, control supplies to various panels / systems. For each load and auxiliary, one separate feeder shall be provided. Duplicate feeders shall be provided for control relay panels, switchgear panels etc. In addition, the following feeders shall be provided in switchboard.

a) Spare feeders - 20% of each type and rating with a minimum of two (2) nos. feeders. This is the minimum quantity at the time of handing over the plant.

b) 240V, 1 phase space heating module for Switchboard – 1 No.

iii) Current ratings:

a) The short circuit current rating of the switchboard shall be arrived at considering the contribution from charger & battery with (>10%) margins.

b) The continuous current rating of the bus bars, incomer for 220V DC switchboards shall be the maximum D.C. load (excluding the momentary load, as required) on the bus plus 20% margin rounded off to the next higher standard rating.

iv) Specific requirements

a) DC switchboards shall comply with all the requirements of this specification.



b) Positive and negative bus bars in the DC switchgear shall be completely segregated from each other by sheet steel partitions.

c) Module details:

v) Incomer:

The incomer modules shall be ACB / MCCB controlled. Each incomer shall be provided with:

a) Ammeter & voltmeter

b) Earth fault relay with potential free contact for remote annunciation.

c) Ammeter to read earth fault current

d) Under voltage relay with timer

e) Indicating lamps for ON, OFF, earth fault, under voltage conditions (22.5mm size LED)

f) One current and one voltage transducer for remote indication.

g) Necessary hardware & circuitry for fault alarm and for lamp test & reset.

vi) Outgoing feeders

a) These feeders shall have DC MCCB "ON" & "Fault" indicating lamps, supply supervision relays, lamp test, accept & reset push button through common alarm module.

b) The feeders rated 200Amps & above shall be provided with a shunt & ammeter.

vii) 230V, single phase space heating module shall be provided with incoming side switch fuse, suitably rated 415V / 230V cast resin type transformer (expected heating loads of the switchgear and the connected motors + 30% margin), secondary fuse, supply indicating lamp and connection to space heating buses. The 415V power supply for these modules shall be obtained from the 415V switchgear.

viii) The calculation for rating of resistors & range of timers selected shall be subjected to PURCHASER's approval.

ix) Additional details refer LV switchgear specification.

x) DC board design should be such that the incomers and bus coupler shall be mounted at distance on the DC board to avoid human error while operation and Bus coupler back side panel should have different colour for easy identification.

xi) Switchgear - Should be provided with proper LOTO arrangement.

xii) Metering for the remote monitoring of voltage, current & other parameters shall be available at plant SCADA in control room. It shall be provided for incomers as well as for critical feeders.

15.10 Tests

i) All routine tests shall be conducted as per the relevant standards for battery, battery chargers and DCDBs.



ii) Type Tests: Performed at Manufacturer's works or Valid type test reports on identical rating and type of cell issued by an authorised test house shall be furnished.

iii) Acceptance Tests: Acceptance tests as per relevant standards shall be performed at vendor's works. Also, acceptance tests shall be performed at site after installation and commissioning of the battery including capacity test and test for voltage during discharge.

iv) A loading resistor bank which can be automatically controlled using time and current signals along with the charger shall be supplied to facilitate discharging of voltages as part of routine maintenance tests.

15.11 Tests for Battery Chargers

15.11.1 The following routine tests shall be conducted at Vendor's works:

i) Visual checks for dimensions and general arrangement.

ii) Wiring checks

iii) Functional checks

iv) Voltage regulation for rated input supply for loads from 0-100%

v) Load test to show the charger can deliver the rated duty without the current limiter device operating

vi) Ripple measurement by oscilloscope at different loads

vii) Demonstration of guaranteed efficiency and power factor

viii) Insulation test (with 500V Megger)

ix) High voltage test, excluding electronic controller, at 2kV AC for one min

x) Heat run test shall be conducted at full load for 24hours at the vendor works on charger

xi) Checking of DC charger system monitoring and associated communication system

xii) Checking of auxiliary devices, protective devices & control equipment

Certified copies of reports of all type tests carried out on similar type and rating of various equipment (offered under this contract) within last five years from the date of submission of Bid shall be furnished to the Purchaser for review and approval. In case the type test reports are not found to be meeting the specification requirements, the VENDOR shall conduct all such tests under this contract free of cost to the Purchaser and submit the reports for approval.

xiii) Heat run test on each type of battery charger.

15.12 Tests for DC Distribution Board

i) All routine tests as per applicable standards shall be conducted on the board.

ii) Valid Type test reports on identical switchgear issued by an authorised test house shall be furnished.

15.13 Layout Requirements for the Equipment / System

i) Batteries of the non-seal type shall be in enclosures with outside vents or in well-ventilated rooms, so arranged as to prevent the escape of fumes, gases, or electrolyte spray into other areas.

ii) Ventilation shall be provided to ensure diffusion of the gases from the battery to prevent the accumulation of an explosive mixture. Well-designed dust free ventilation system should be installed in battery charger room.

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iii) Floors shall be of an acid resistant construction tile or be protected from acid accumulations.

iv) Facilities (eye wash fountains and shower) for quick drenching of the eyes and body shall be provided within 25 feet of the work area for emergency use.

v) Red light indication shall be provided for eye wash in battery room.

vi) Facilities shall be provided for flushing and neutralizing spilled electrolyte, for fire protection, for protecting charging apparatus from damage, and for adequate ventilation for dispersal of fumes from gassing batteries.

vii) When racks are used for the support of batteries, they should be made of materials nonconductive to spark generation or be coated or covered to achieve this objective. Acid resistant paint shall be used.

viii) Doors into rooms or buildings containing stationary lead-acid battery systems shall be provided with approved signs. The signs shall state that the room contains lead-acid battery systems, that the battery room contains energized electrical circuits and that the battery electrolyte solutions are corrosive liquids.

ix) The door shall have louvers at the bottom for facilitating ventilation.

x) Safety instructions detailing the hazards of the work to be carried out must be available in battery room area.

xi) Seismic Protection: Battery systems shall be seismically braced according to the building code.

xii) The battery room shall be provided with corrosion resistant, flame proof, industrial luminary/ fittings. Light fittings should be fixed to the wall or suspended at more than 50 cm from the ceiling, but not vertically above the batteries or charging units.

xiii) The switch for these Light fittings shall be brought out of battery room and shall be provided at the entrance door of the battery room.

xiv) The battery room shall be provided with rate of rise of heat detector (ROR) for fire detection and alarm system.

xv) Battery Room Ceiling: Preferably the room ceiling should be flat to ensure that pockets of trapped Hydrogen gas do not occur, particularly at the ceiling, to prevent the accumulation of an explosive mixture.

xvi) Battery rooms must be dry and should have height of 2 m above the operating floors.

xvii) Fire Protection: Carbon Dioxide portable fire extinguishers should be kept handy.

xviii) Hoisting Equipment: Electrical hoisting equipment should be used with nonconductive hoisting belts.

xix) The arrangement of battery cells i.e. no. of rows and tiers shall be based on space availability. The height of rack shall not be more than 4 feet so as to have easy access for acid filing / maintenance work.

xx) Battery room must be laid out in such a way that there is adequate space for work to be carried out with appropriate tools.

xxi) The battery cells shall be numbered prominently to keep track of each flame cell during O&M phase.

xxii) Battery room shall be provided with flame proof exhaust fan for forced ventilation and the failure of the exhaust shall generate an alarm.

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xxiii) Charger isolation switch should be identified and located in an accessible location.

xxiv) Fresh air fan and exhaust fans provided for the battery room should be explosion proof. Also, the both these fans shall be provided with steel net & auto-louvers so that the louvers get closed automatically after switching of the fans, to avoid entry of rodents and reptiles inside the battery room from the openings of the wall provided for fans.

xxv) Hydrogen gas sensors to be installed in the battery room for the detection and alarm of hydrogen gas inside the room. These sensors shall be compatible for getting connected to Tata Power SCADA network for displaying the value of Hydrogen gas and generating alarms.

xxvi) The interconnection between two row of cells shall be by means of cable which is routed below the floor so as to maintain a free passage between the rows.

15.14 Employer's Specification

Sl. No.	Description	Unit	Client's Specification
1	**Battery**		
1.1	Application		220 V DC system for Switchgear & control systems
1.2	Type of Battery		Lead Acid Plante high discharge
1.3	Number of battery banks required		220 V: 1 set (2 x 100%),
1.4	Number of cells in each bank in series (Approximate)		To be finalised during detailed engineering
1.5	Ambient conditions	ºC	50
1.6	D. C. System voltage	V	220 V DC system for Switchgear & control systems
1.7	Design margin to be considered		20%
1.8	Ampere hour capacity of battery at 27ºC.		
1.9	10hours rate to give final cell voltage of 1.85volts/cell for Lead acid Plante battery.	Ah	BIDDER to decide during detailed engineering
1.10	10hours rate to give final cell voltage of 1.14volts/cell for Ni-Cad battery.	Ah	BIDDER to decide during detailed engineering
1.11	Layout drawing No. (If any)		
1.12	Mounting Arrangement		To be finalised during detailed engineering
1.13	High discharge test required	Yes / No	If yes,
1.14			Amps :
1.15			Time :
1.16			End cell voltage :

Sl. No.	Description	Unit	Client's Specification
1.17	Charging method proposed		Float/Trickle
2	**Battery Charger**		
2.1	General		Free standing floor mounting Float charger and Float-cum-boost charger
2.2	Number required	Sets	220V: 2x100% of (FC+FCBC),
2.3	Type		Solid-state, full wave, fully controlled, three phase bridge, suitable for continuous duty application.
2.4	DC System Voltage (Nominal)	V	220 V DC system for Switchgear & control systems
2.5	DC System Earthing		Unearthed
2.6	Ambient Design Temperature	ºC	50
2.7	DC Bus Load		
2.8	Total continuous DC load	A	During detailed engineering
2.9	Short time loads (Additional to continuous loads)		During detailed engineering
2.10	Testing of DC lights / Facia lamps	A sec	During detailed engineering
2.11	Starting / Running current of Largest connected DC Motor	A / A sec	During detailed engineering
2.12	DC system Fault level & duration	kA	***kA for 1 sec
2.13	No. of cells	No.	As per system voltage
2.14	End cell voltage	V	1.85
2.15	Nominal Float voltage (V)	V	2.25 V/ cell
2.16	Boost voltage (Maximum) (V)	V	Bidder to furnish the detail along with offer
2.17	AH Capacity of Battery	AH	Bidder to furnish quoted AH capacity and battery sizing as per system requirement
2.18	AC system data		
2.19	Supply		
2.20	Volts	V	415
2.21	Phase		3 Phase

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Sl. No.	Description	Unit	Client's Specification
2.22	Hz	Hz	50
2.23	Variation of parameters		
2.24	Variation in supply Voltage		±10%
2.25	Variation in supply frequency		±5%
2.26	Combined Variation		10%
2.27	Type of earthing		Solidly earthed
2.28	Performance		
2.29	DC voltage setting adjustment for float charger	%	±10% of nominal voltage
2.3	Voltage stabilisation for constant voltage regulator	%	±1% of set D.C voltage, with AC input variation as in 3.2
2.31	Maximum permissible variation in DC voltage (no load to full load)	%	±1%
2.32	D.C. voltage setting adjustment for boost charging	%	70% to 100% of max. Boost charging voltage.
2.33	D.C. current adjustment for boost charging	%	30% to 100% of max. boost charging current
2.34	Current stabilisation for constant current regulator for boost charger	%	±2%
2.35	Minimum permissible power factor at rated continuous load		0.85
2.36	Permissible ripple content at rated continuous load	%	1% (maximum)
2.37	Maximum permissible harmonics with or without battery	%	5%
2.38	Miscellaneous		
2.39	Cable entry		During detailed engineering
2.40	Cable sizes		
2.41	Battery	Sq.mm	
2.42	DC output	Sq.mm	
2.43	AC input	Sq.mm	
2.44	Potential free contacts	Yes / No	YES
2.45	Degree of protection of charger cubicle		IP 42
2.46	Overall efficiency of charger		>80%
2.47	Standard reference drawings enclosed		YES
3	**DC Switchgear**		

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Sl. No.	Description	Unit	Client's Specification
3.1	Switchgear and busbar rating		During detailed engineering
3.2	Rated voltage	V	220 V DC system for Switchgear & control systems
3.3	Maximum voltage at which all components shall operate satisfactorily	V	242 V for 220 V DC system
3.4	Continuous current rating of bus bars under site reference ambient temperature		To be decided during detailed engineering
3.5	Reference ambient temperature	ºC	50
3.6	Maximum temperature of bus bars droppers and contacts at continuous current rating under site reference ambient temperature		90ºC for non-silver-plated joints 105ºC for silver plated joints
3.7	Short circuit current withstand for bus bars and droppers		
3.8	short time (1sec)	kA	As per calc.
3.9	Dynamic rating	kA (Peak)	
3.10	Switchgear constructional requirements		
3.11	Thickness of sheet steel		FRAME / DOORS / COVERS
3.12	Cold rolled	mm	2.5 / 1.6 / 1.6
3.13	Hot rolled	mm	- / 2.0 / 2.0
3.14	Degree of protection		IP 52
3.15	Colour finish shade as per IS		
3.16	Interior		Glossy White
3.17	Exterior		RAL 7032
3.18	Earthing bus		50x10mm (GS)

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15.15 Applicable Standards

Sl. No.	Description	Unit	Client's Specification
1	**Battery**		
1.1	General requirement and method of tests for valve regulated battery		IEC: 60896-2
1.2	Water for storage battery	IS : 1069	
1.3	Synthetic separator for lead acid batteries	IS : 6071	
1.4	Recommended practice for sizing lead acid batteries for stationary applications		IEEE : 485
1.5	Standard for safety of flammability of plastic materials for parts in devices and appliances testing		UL: 94
1.6	Rubber and plastic containers for lead acid storage battery	IS: 1146	
1.7	Stationary valve regulated lead acid batteries	IS: 15549	
2	**Battery Charger**		
2.1	Environmental tests for electronic and electrical equipment	IS 9000	
2.2	Environmental requirements for semiconductor devices and integrated circuits	IS 6553	
2.3	Factory built assemblies of switchgear and controlgear for voltages upto and including 1000V A.C. and 1200vd.c.	IS 8623	IEC 61439 / IEC 60947
2.4	Degree of protection	IS 2147	
2.5	Semi-conductors converters	IS 4540	IEC 60146
2.6	Semiconductor rectifier equipment safety code	IS 6619	
2.7	Low voltage switchgear and control gear assemblies-general rules	IS/IEC:61439-1	

15.16 Schedule of Mandatory Spares

Sl. No	Description	Unit	Quantity
1	**220 V Battery**		
1.1	Spare cell (complete) for each 220 V type and size used.	nos	10
1.2	Insulators for racks in percentage of total quantity used for 220 V battery set in percentage of total quantity of each type used.	(percentage)	10%
1.3	Inter cell Connectors suitable for making connections for 220 V of each size used.	nos.	20
1.4	Connectors suitable for making connections for 220 V each size of cable to the battery terminals.	nos.	5
1.5	Vent Plugs, caps of each type, Connecting Bolts/Connectors of each type used for 220 V.	nos.	10
1.6	Fuses of each size used in 220 V System	sets	2
1.7	Electrolyte used in percentage of total quantity used for each 220 V System in power house & switchyard	(percentage)	10%
2	**Battery Chargers**		
2.1	Electronic circuit board cards of each type used.	no	1
2.2	MCCB of each type/rating used	nos.	1
2.3	Air Circuit breaker of each type/rating used	nos.	1
2.4	Blocking diode assembly of each type/rating used	nos.	2
2.5	Rectifier transformer (Dry type) and choke of each type/rating used	nos.	1
2.6	Silicon Controlled Rectifier/Complete Thyristor Bridge/ Module of each type/rating used	nos.	4
2.7	DC Voltmeter of each type/rating used	nos.	2
2.8	DC Ammeter of each type/rating used	nos.	2
2.9	Shunt Resistor of each type/rating used	nos.	2
2.10	Contactor of each type/rating used	nos.	1
2.11	Selector switch of each type/rating used	nos.	2
i)	Indicating lamps of each colour with lamp covers used in each charger	nos.	5
ii)	Trip element of each size/type used	nos.	1
iii)	HRC fuses (Auxiliary Fuse of each type/size/rating used)	nos.	3
iv)	Heat sink for SCR of each type/size/rating used	nos.	3
v)	Semi Conducting Type Fast Fuse of each type/rating used	nos.	6
3	**Main and Sub DC Distribution Boards**		
3.1	MCCB of each rating/type with door operating handle in percentage of total quantity used. Minimum one number shall be supplied if the percentage is in fraction.	(percentage)	10%
3.2	Contactors of each rating and type used	nos.	2
3.3	Indicating lamps with lamp covers of each type used	nos.	4

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Sl. No	Description	Unit	Quantity
3.4	Terminal blocks	nos.	10
3.5	Selector switch of each type and rating used	nos.	2
3.6	Indicating instruments with transducers of each type /rating used	nos.	2
3.7	Trip element of each type/size used	nos.	2
3.8	Relay of each type and rating used	nos.	1
3.9	HRC fuses of each type/size used	nos.	3
3.10	Sensors, transducers etc. of each type and rating used	nos.	1
Note:-Set means quantity required for one unit			

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CHAPTER 16: UNINTERRUPTIBLE POWER SUPPLY SYSTEM

16.1 Scope of Work

This specification covers the requirements of Uninterruptible Power Supply (UPS) to critical AC load systems, which have stringent requirements, imposed on voltage and frequency regulation, harmonic content, and transient recovery, that instrumentations, plant automation, substation automation system, FDA, Communication, CCTV, computers/HMI, emergency lighting circuit, etc. as required.

i) 230 V,50 Hz single phase uninterruptible power supply system (UPS) shall be sized to continuously carry 100% of all instruments, control, and computer loads, fire alarm and detection, communication, and any other AC load that cannot tolerate interruption of power for safe and reliable operation of the power plant.

ii) Following list of items shall be provided for the projects

a) 2 sets at Powerhouse control room (1 Main and 1 Stand By).

b) 1 set at SCADA System.

c) 1 set at DAM Gate control building.

d) 1 set at Chaplangchhu Intake control building.

UPS rating will be based on load list, which would be finalised during detail design stage. All UPS shall be suitable for minimum 1 Hour Back up time operation at rated load.

16.2 Codes and Standards

i) The design, material, construction, manufacture, inspection, testing and performance of UPS shall comply with all currently applicable statutes, regulations, and safety codes in the locality where the equipment will be installed. Nothing in this specification shall be construed to relieve the VENDOR of this responsibility.

ii) The codes and standards mentioned in the various specifications and requirements specified in the enquiry document shall be latest as on the day of award of contract of the works unless otherwise specified. Contractor shall be responsible to inform to the Consultant/Owner in case of any revisions/reaffirm/ amendment in the relevant codes and standards after the date of award of contract within 30 days of the issue of such revision/re-affirm/amendment of the code/ standard. Consultant/ Owner may approve use of the earlier code/ standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed.

iii) The VENDOR shall ensure that instruments and gauges to be used for testing and inspection shall have valid calibration and the accuracy can be traced to National and International Standards as applicable.

iv) In case of conflict between the standards and this specification, the more stringent of the two shall govern.

16.3 System Requirements

i) The UPS system shall be true on-line static type and the components of UPS shall isolate power line transients, frequency, and voltage variations. The UPS shall provide no-break power supply to the critical loads under normal conditions, during outages in the input power and during failure / mal operation of the main components of the UPS by switching to the alternate supply.

ii) Static UPS systems shall be parallel redundant (100% of redundancy) shall be provided.

iii) Parallel redundant operation with bypass to regulated supply.

iv) (N+N Configuration (2 x 100%) (Drg. No. TCE.M2-EL-AU-S-2863)

v) UPS system shall be working in Parallel Redundant configuration having two sets of 100% rectifiers, batteries, static transfer switch and inverters and shall share the load. Under normal conditions, when AC mains power is available, both the rectifiers shall operate independently and supply DC power for float / boost charging the batteries and simultaneously to inverters. In case of failure in any one rectifier, the faulty rectifier unit shall automatically get disconnected, and the entire load shall be fed from the other UPS. Each rectifier shall be designed for feeding inverter load and float / boost charging of the battery to its rated capacity within 10 hours.

vi) Normally both inverters will be synchronized with each other and with bypass supply. The two inverters shall operate in parallel and share the load equally. When a disturbance / fault occurs in any one of the inverters, the faulty unit shall automatically get disconnected, and the entire load shall be fed from the other inverter. In case, both inverters develop a fault, the complete load shall be transferred to bypass supply through static transfer switches and retransfer of load from bypass to inverter supply shall be automatic/manual.

vii) A manually operated make before break changeover switch/MCCB shall be provided to bypass the UPS power circuits (inverters and static switches) for maintenance and repair purposes.

16.4 Design Requirements

All UPS components, i.e., rectifier, inverter, static switch, by-pass switch, isolation transformer associated controls shall be mounted in floor mounted, sheet steel panel. In case of 3ph output UPS, it shall be transformer less design on the input side of Rectifier. The panels shall be designed for continuous operation for the ambient conditions as defined. In case of vented type batteries, the battery shall be separately installed in a battery room. In case fans are required for cooling, N+1 Redundancy shall be provided to ensure rated output of the UPS.

16.4.1 Battery

i) The battery backup time, number and type of batteries shall be as specified in Data Sheet-A1. The BIDDER shall choose the required voltage of the battery. The AH capacity of battery shall be chosen by BIDDER, based on the battery backup time / duty cycle, and minimum ambient temp. specified in Data Sheet-A1, and the guaranteed DC/AC efficiency of the UPS system offered.

ii) BIDDER shall furnish calculation for sizing of the battery based on the requirements specified in Data Sheet-A1.

16.4.2 Rectifier

i) The rectifier shall essentially be IGBT type for all ratings of three phase UPS. For single phase UPS full controlled full wave type thyristors rectifier shall be used. The thyristor type rectifier shall be 6 pulse/12 pulse design with input isolation transformer. For Redundant UPS design the two rectifier input isolation transformers shall have vector grouping and connections to ensure 12 pulse operation seen from the source side. The rectifier shall be provided with soft start feature. The rectifier shall have features for temperature compensation charging of the batteries.

ii) The rectifier shall be capable of supplying the inverter full load, in addition to charging the fully discharged batteries in 8 to 10 hours or as recommended by battery manufacturer and then maintain the battery on trickle charge mode. The rectifiers shall automatically share the load during parallel operation.

16.4.3 Inverters

i) The inverter shall be of IGBT type. The same shall be of PWM (Pulse Width Modulation) type. The inverter system shall be complete with necessary filters to limit

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the harmonic distortions to the load. The system shall have features to prevent deep discharge of battery.

ii) High speed pulse balancing electronic over voltage/under voltage protection shall be part of the system.

16.4.4 Static Switch

i) The static switch shall comprise thyristors connected in anti- parallel configuration, enabling loads on each branch circuit to be connected to the inverter of the other branch circuit or to the stand-by regulated AC supply.

ii) The current rating of the static switch shall be not less than the continuous full load rating of the branch circuit and short time rating of 1000% for 10 milliseconds.

iii) Automatic initiation of the transfer from a faulty branch circuit to either a healthy branch circuit or the stand-by regulated source shall be accomplished during following conditions:

a) Inverter failure.

b) Loss of inverter AC output.

c) Load over current (in case of non-redundant UPS with static bypass to regulated supply).

16.4.5 Regulated Stand-By AC Supply

i) Regulated stand-by AC supply shall be derived from stand-by source through a 3 ph servo- controlled voltage stabilizer (SCVS) and a 3 ph/3ph-1ph Delta-Vee connected adequately rated isolation transformer.

ii) The voltage regulation and transient response shall be as specified in Data Sheet-A1.

16.4.6 Circuit Protection

The following devices shall be provided to protect the UPS system:

i) AC input circuit breaker to Rectifier unit.

ii) AC input circuit breaker to supply stand-by transformer / voltage stabiliser.

iii) DC circuit breaker for battery output.

iv) Fast acting semiconductor fuses.

16.5 Indications & Annunciation

i) The UPS system shall be provided with necessary meters, mimic diagram, local indication / alarm conditions.

ii) High resolution digital display unit shall be provided for continuous monitoring of the UPS operation. The control system shall operate on Windows or eqvt. platform. The following operating conditions shall be annunciated.

iii) Alarm Indication:

a) System fault
b) Rectifier charger failure
c) Inverter failure/ faulty
d) Battery under voltage
e) End of Battery Discharge
f) UPS over temperature
g) Overload
h) Static transfer to stand-by
i) Transfer inhibited.
j) Overload shutdown

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k) Emergency shutdown
l) Battery circuit breaker / switch open
m) AC Main failure
n) AC stand-by source mains failure
o) AC stand-by frequency out of range
p) Manual bypass ON
q) Fan failure
r) Asynchronous condition
s) Control power failure

iv) Status Indication on Mimic:

a) Mains on
b) Rectifier on
c) Battery on load
d) Inverter on
e) AC Stand-by source on
f) Inverter on –load
g) Manual by-pass on
h) Load on static bypass.

v) Display of measurements:

a) Inverter output phase-to-phase voltages
b) Inverter output currents
c) Inverter output frequency
d) Voltage across battery terminals
e) Rectifier input phase-to-phase voltages
f) Rectifier input currents
g) Active and apparent power
h) Power factor
i) DC voltage & Current

16.6 Remote Interface

Bidder shall consider the UPS integration with remote Plant SCADA for monitoring of all annunciations, alarm, and metering parameters. UPS shall have Modbus TCP IP compatibility to communicate to remote system. Necessary protocol converters, communication gateways etc., shall be provided by bidder as required.

16.7 Harmonics

Necessary input and output filters shall be provided, or the Rectifier and Inverter design shall be such that the harmonics injected back to the source and to the load shall be within limits specified in IEEE-519 at the point of coupling of the UPS to the system. The fault level of the system at the point of common coupling shall be as specified in Data Sheet-A1.

16.8 AC Distribution Board (ACDB) & Other Miscellaneous

i) ACDB (with suitable MCB rating) shall be supplied along with the UPS.

ii) MCCB boxes for Batteries

iii) Necessary cables & accessories.

16.9 System Earthing

The VENDOR shall clearly bring out the earthing philosophy to be adopted for the UPS electronics, protective earthing (PE) and neutral earthing. The requirement of separate clean earth independent of the plant electrical system earth shall be clearly brought out. All metallic

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non-current carrying parts of the Panel shall be bonded together and connected to the earth bus made of GI/Cu.

16.10 Tests On Ups

i) Type test reports, not older than five (5) years as on date of Bid submission, for the UPS panels of similar rating shall be submitted along with the Bid.

ii) Routine tests on the complete UPS system shall be carried out as per relevant standards for each major sub-system in the UPS, viz., Rectifier, Inverters, batteries, stand-by supply, ACDB etc.

iii) Type and routine tests certificates for all components used in the UPS system shall be furnished. Tests for components shall be as per relevant standard specifications indicated in Data Sheet-A2.

iv) BIDDER shall furnish the quality assurance plan for the equipment offered. The quality assurance plan shall include bought out components and assemblies used in the UPS system.

v) System tests shall be performed on the completely assembled UPS system. System tests shall include frequency regulations, Voltage regulation, current limiting feature and harmonic content tests in addition to the tests to prove the functional requirements such as synchronization with range of adjustments, transfer of static switches for conditions of loss of square wave, overload and under voltage conditions.

vi) Endurance test on static switches shall be performed for not less than 10 transfer / retransfer cycles at full load.

vii) Heat run test shall be carried out on each branch of UPS including bypass (if provided) and on overall UPS system at rated load under relevant ambient conditions for a period of 8 hours. This test shall be conducted as a routine test on all UPS being supplied.

16.11 Spares

BIDDER shall include list of spares with quantities as recommended for three years trouble free operation.

16.12 Employer's Specification

Sl No	Item	Unit	Client Specification
1	**General**		
1.1	Application		For supply to critical load of instrumentation & controls of turbine / / process control instruments/ Servers/ PC's/Hub Rooms / as per project scope.
1.2	Power rating at load PF 0.8 lagging		KVA continuous (Sizing to be considered with Load, 10 % design margin, efficiency, temperature correction factor, not more than 80% loading, etc.)
1.3	Quantity (nos.)		2 sets at Powerhouse control room (1 Main and 1 Stand By). 1 set at SCADA System. 1 set at DAM Gate control building. 1 set at Chaplangchhu Intake control building.
1.4	Method of energy storage		Battery back -up
1.5	Type		Parallel Redundant with static bypass to regulated supply
1.6	Parallel Redundant configuration		N+N (2 x100%)
1.7	Installation		Indoor, Air-conditioned Room
1.8	Design Ambient Temperature (°C)		50 °C
1.9	Relative Humidity		Up to 95% Non-Condensing
1.10	Fault level of the system	kA	50 kA for 1 sec
2	**Enclosure**		
2.1	Sheet steel thickness		2mm, CRCA for doors and 1.6mm CRCA for side covers
2.2	Degree of protection as per IS-13947		IP42 if located in Non-air-conditioned area /IP20 if located in air-conditioned area.
2.3	Painting		
i)	Exterior		RAL 7032
ii)	-Interior		Glossy White
2.4	Cable Entry		Bottom / Top
2.5	Acoustic Noise level Measured at a distance of 1m		60 – 65 dBA up to 120KVA 65 – 75dBA above 120KVA
2.6	Space heater, 240V, 1 Ph		Required
3	**Ups System**		
3.1	Input		
i)	Supply voltage		415 V, 3 PH, 3 W/4W, 50 Hz AC, Non-Effectively earthed / effectively earthed.
ii)	Allowable Variation		
a)	Voltage		+ 10%
b)	Frequency		+ 5%

Sl No	Item	Unit	Client Specification
c)	Combined voltage + frequency		10%
iii)	Harmonic content (Input)		<5%
3.2	Output		
i)	Output voltage		240 V, 1 PH
ii)	AC voltage accuracy (steady state) over entire load, load PF & DC voltage range.		+ 2% for balanced load
iii)	Transient voltage regulation		8% at 100% load step
iv)	Transient recovery		Return to steady state condition within 50 ms after disturbance.
v)	Voltage wave from		Sinusoidal
vi)	Range of adjustment of AC output voltage		+ 5% at rated load
vii)	AC Harmonic content (THD-Voltage)		As per IEEE 519
viii)	Phase displacement for three phase outputs		1200 + 10 for balance load 1200 + 30 for 20% unbalanced load.
ix)	Nominal frequency		50 Hz
x)	Frequency regulation (Without static by-pass source)		+ 0.1 %
xi)	Frequency regulation (With static by-pass source)		± 2 Hz
3.3	AC standby supply		
i)	Servo controlled voltage stabilizer (SCVS)		Required
a)	Rating		To match UPS continuous rating
b)	Overload capacity		10 times rated current for 100ms
c)	Input voltage phase & frequency		415V + 10% 3 ph 3/4 wire 50 HZ
d)	Percentage voltage regulation		+ 2%
e)	Spike busters / surge suppressors and input filters		Required
3.4	Maintenance bypass switch		Required
4	**Battery**		
4.1	No. of 100% capacity batteries		
4.2	Type of battery cell		Lead acid, (Plante /Tubular) or Nickel Cadmium
4.3	Battery backup time		2 hours

Sl No	Item	Unit	Client Specification
4.4	**Mounting Arrangement**		Open Type Rack: Single tier / Multi-Tier
5	**Rectifier**		
5.1	Recharge time on battery boost charge		As per Battery manufacturers recommendation
6	**Inverter**		
6.1	Overload Capacity		125% for 10 Min.
			150% for 1min
			300% for 4 milli seconds
6.2	Synchronising		
i)	-Between inverters		Required
ii)	-Between inverters and standby supply		Not Required
6.3	Synchronising Range		50 ± 3 Hz (adjustable)
7	**Static Switch**		
7.1	Maximum transfer time		<5ms
7.2	Short time current rating		1000% for 10 milli seconds
8	**Circuit Breaker & Load Break Switches**		
8.1	Type		ACB/MCCB
9	**AC Distribution Board**		Required
9.1	Type		Integral or separate
9.2	Construction		Modular, single / double front
9.3	Busbars		Aluminium/Copper
9.4	Incoming		ACB/MCCB
9.5	Outgoing		MCB/MCCB
9.6	Cable entry facility		Top / Bottom
9.7	ACDB construction		Refer LV Switchgear section
10	**Remote Communication protocol**		Modbus TCP IP / IEC 61850

16.13 Applicable Standards

Sl No	Description	Standard
1	UPS – Method of specifying the performance and test requirements	IEC - 62040 (Part-III)
2	Basic climatic & mechanical durability tests for components for electronic and electrical equipment	IS 9000
3	Transformer and inductors (Power, Audio, Pulse & switching) for electronic equipment	IS 6297
4	Terminals for electronic equipment	IS 4007
5	Degree of protection	IS 13947/IEC60 947-1
6	Semiconductor converters	IEC 60146
7	Semiconductor rectifier equipment code	IS 6619
8	Thyristor converters	IS 5082
9	Emergency std by power systems	IEEE 446
10	Harmonic levels	IEEE 519

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16.14 Mandatory Spares

Sl No	UPS	Unit	Qty
1	MCB/MCCB of each rating	nos. of each type and rating	2
2	Semiconductor fuses of each rating	nos. of each type and rating	2
3	Control cards	nos. of each type and rating	2
4	Thyristors / Power Transistors of each rating	nos. of each type and rating	2
5	Power diodes of each rating	nos. of each type and rating	2
6	Auxiliary relays & Power contactors of each type.	nos. of each type and rating	2
7	Filter capacitors	nos. of each type and rating	2
8	Filter choke	nos. of each type and rating	2
9	Fuses	nos. of each type and rating	2
10	CT and PT	nos. of each type and rating	2

CHAPTER 17: HEATING, VENTILATION AND AIR CONDITIONING (HVAC) SYSTEM

17.1 Scope of Work

Scope of work under this section covers the provision of labour, tools, plants, materials and performance of work necessary for the design, manufacture, quality assurance, quality control, shop assembly, shop testing, delivery at site, site storage and preservation, installation, commissioning, performance testing, acceptance testing, training of Employer's personnel, handing over to KHPL and guarantee for two years of heating, ventilation and air conditioning (HVAC) system, as per the specifications hereunder, each complete with all auxiliaries, accessories, spare parts and warranting a trouble free safe operation of the installation.

The scope of work shall be a comprehensive functional system covering all supply and services including but not be limited to following:

17.2 Air Handling Units (AHU)

i) Three (2W + 1S) nos. Fresh air blower of 50% capacity each including filters, enclosures etc. for supply of fresh air to the entire system, to be located at the Ventilation tunnel portal.

ii) Three (2W + 1S) nos. Air handling units, each of them of 50 % of the required capacity for powerhouse floors and Transformer Cavern including bus duct gallery, connecting gallery and cable tunnel etc.

iii) Three (2W + 1S) nos. Air handling units, each of them of 50 % of the required capacity for Control block.

iv) Two (1W + 1S) nos. Air handling units, each of them of 100 % of the required capacity for air-conditioned area such as Control room, conference room, offices, library, lobby etc.

v) Any other boosters / blowers / AHU's / Fan coil units, Air curtains etc. required to ensure a well-ventilated / air-conditioned system in the powerhouse to maintain a positive draft under all circumstances of operation.

Any other item(s) not mentioned specifically but necessary for the satisfactory completion of scope of work defined above, as per accepted standard(s)/best international practices.

17.3 Exhaust Air Fans

i) Required nos. of exhaust air fans for exhaust of air from the battery rooms.

ii) Required nos. of exhaust air fans for exhaust of air from the toilets, kitchens, first aid room, mechanical workshop etc. at different floors, each of 100% of required capacity.

iii) Minimum four (4) nos. exhaust air fans for exhaust of air from the diesel generator room each of 100% of required capacity.

iv) Required nos. of smoke exhaust fans for exhaust of smoke/air from all ventilated areas including powerhouse floors, control block, service bay, Transformer cavern, galleries bus duct, Cable Tunnel etc. in case of fire.

v) Required nos. fan coil units (FCU) to supply air for four bus duct galleries.

vi) Required nos. of smoke fan for exhaust of smoke from cable tunnel in case of fire with 100% stand by capacity.

17.4 Chillers and Circulating Pumps

i) Three (2W + 1S) nos. Air Cooled Chillers (ACC) units each with 50% of required cooling capacity.

ii) Two (1W + 1S) nos. Circulation pumps for chilled water circuit system along with required instruments & associated accessories.

iii) One (1) no. automatic self cleaning filters along with instrumentation and associated accessories for chilled water circulation circuit.

17.5 Auxiliary System and Miscellaneous Items

i) Air duct distribution system for supply and return air of all HVAC systems, with necessary galvanized sheet metal ducts (for battery room exhaust air system, special rust, acid and corrosion proof ducts etc.), elbows, tees, supports, fixations, including all necessary grills, louvers, outside air louvers, adjusting duct dampers, motorized fire dampers, heating and cooling insulations, etc.

ii) Central computerized control panel for HVAC system complete with all wiring, instrumentation and associated accessories etc.

iii) Any additional AHUs, pumps, chillers, fans, FCU and other items/equipment felt necessary during detailed engineering.

iv) Local control panels for air handling units, air cooled chiller units, circulation/cooling water pumps, automatic filters, exhaust fans, FCU etc.

v) Expansion tank for chilled water circuit along with necessary interconnected piping for bringing the portable water from makeup water tank.

vi) Insulation with vapour proof cladding for exposed pipes, wherever applicable.

vii) Chilled / Cooling water distribution system along with necessary insulation, valves, fittings, piping, filters, regulating orifices, all type of consumables and other materials.

viii) Necessary instrumentation pressure gauges, pressure switches, temperature gauges, temperature switches, flows indicator, flow relay/transmitter and humidity sensing devices/instruments etc.

ix) Provision of necessary contacts and/or ports for integration with plant SCADA and fire fighting system.

x) Spare parts in accordance to “Spear List”.

xi) Tools and instruments.

Any other item(s) not mentioned specifically but necessary for the satisfactory completion of scope of work defined above, as per accepted standard(s) / best international practices.

17.6 Air Curtains

provide an effective air barrier at the entrance of the underground powerhouse, preventing the ingress of dust, insects, humid air, and temperature exchange, thereby maintaining internal environmental conditions and enhancing HVAC efficiency.

Heavy-duty industrial air curtain, ceiling or wall-mounted, suitable for high-traffic and high-pressure differential environments at the main entrance of the Powerhouse door from the MAT.

i) Effective Air Barrier Height: Up to 6.5 meters (6.5m width)

ii) Noise Level: ≤ 65 dB at 1 meter

17.7 Specific Parameters and layout Conditions

17.7.1 Layout and General Arrangement

The total Powerhouse building shall be divided into following areas for heating, ventilation and air conditioning as indicated in HVAC flow diagram no. KHPP-ME-6017-PI-60006.

17.7.2 Cooling Water Circuit

The source of raw water for the primary cooling water circuit shall be the cooling water sump provided in the MIV floor. Two (1W + 1S) nos. horizontal centrifugal pumps shall be installed one in each dry pit of cooling water system at EL 1002 for meeting the requirement of primary

cooling water circuit. The primary cooling water circuit shall be provided with automatic self cleaning filters and necessary valves.

The source of secondary cooling water circuit shall be the common expansion tank of cooling water circuit. Secondary (closed loop) water circuit shall be provided with two (2) nos. centrifugal pumps, check valves, flow meters, isolation valves, and automatic self cleaning filter.

The primary and secondary system shall be provided with check valves, flow meters, isolation valves and necessary instrumentation, which shall be finalized during detailed engineering to fulfil the intended duties and control philosophy. Necessary gate valve with motorized valves in series shall be provided in filter suction side for isolation and auto controls. The source of chilled water circuit shall be the separate expansion tank with automatic filling valve in the filling line, which shall be filled from portable water of makeup water tank

17.7.3 Design Considerations

The project is situated in the Eastern Himalayan region. The raw water filters and pumps may be expected to handle water with silt concentration as per the petrographic analysis of silt in water and chemical analysis of water detailed in clause 4.2.1.3, Section-1 appended as Annexure-III, General Technical Requirements'.

The Contractor shall critically study the silt data and chemical analysis of water and take the same into account in designing the HVAC system susceptible to abrasive effect of silt, making all such specific provisions and measures including selection of materials, surface coating, corrosion protection/ painting which will help to resist silt erosion/abrasion and enable easy and quick maintenance / replacement of worn-out components.

17.7.4 Fire Safety

The Contractor shall coordinate with the fire fighting system Contractor for designing the ventilation system providing necessary means and pressure to stop the supply of air to the affected area and to evacuate smoke and toxic particles from the place of origin to the outdoors in a manner that it does not interfere with the operation of plant and to allow for emergency access and egress.

17.8 Rating and Functional Characteristics

The system design shall be based on but not limited to criteria, factors, and details outlined subsequently.

17.8.1 Design Condition

Design maximum temperature and relative humidity for the design of the HVAC system in summer and winter shall tentatively considered as follows:

Summer - 36 degree C & 100 % RH

Winter - 25 degree C & 94 % RH

17.8.2 Indoor Air Conditions

All air conditioned areas (Control room, Office room & Conference room etc.) catered by air handling units shall be maintained at temperature of 25°C ±1°C and at relative humidity of not more than 55%.

Other areas catered by air handling units in the powerhouse as well as control block floors, transformer cum GIS cavern, bus duct gallery including connecting gallery etc. shall be maintained at temperature of 22°C ±5°C at relative humidity not exceeding 60%.

The HVAC systems shall be designed and erected to guarantee the room conditions according to the design requirements. The internal heat production from electrical and mechanical equipment shall be calculated by the Contractor. Final calculation shall depend on the design data of individual manufacturer's equipment.

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17.8.3 Air Changes per Hour

All ventilated and air conditioned areas shall be designed to maintain a positive pressure within the powerhouse with at least one fresh air changes per hour in tunnel areas. Air changes in other areas shall be in accordance to IS 4720.

17.8.4 Noise Levels Rejection Limit for Short in Output and Efficiency

The Employer reserves the right to reject the turbine if the tested values of either weighted average efficiency or the rated output of 150MW @ generator terminals, at design head of 761.5 m falls short by two (2) percent or more of the corresponding guaranteed values during field acceptance tests.

17.8.5 Tender Evaluation on Account of Efficiency Differences

For the purpose of comparison of bid, the quoted prices shall be enhanced by capitalization for the shortfall in efficiency and output at the rate of Nu/Rs.104,00,000.00 (Ten million four hundred thousand) per one hundredth of 1% (0.01%) difference to the highest value quoted by any one of the bidders. Loading for all the four turbines shall be considered for equalization. No change in the values of efficiency/output Quoted in guaranteed & technical particulars shall be permitted after opening of bids & evaluation will be carried out on the basis of information furnished by the bidder in the bid.

The noise level when measured at (one)1 m from source, caused by operation of the HVAC systems shall not exceed:

i) 45 dB (A) in rooms as in the control rooms, conference rooms, offices, record room, library and reception room and 60dB (A) in other areas,

ii) 70 dB (A) for all diffusers grills and 85 dB (A) for motors, fans, etc.

iii) Silencer, as required, shall be provided to guarantee the above sound levels.

17.8.6 Air Velocities in Ducts

In main ducts 370-670 m/min (6 – 11 m/sec)

In branch ducts 250-550 m/min (4 – 9 m/sec)

In occupied room zones 120-180 m/min (2 - 3 m/sec)

17.9 Performance Guarantee

The Heating, Ventilation and Air Conditioning (HVAC) system along with all auxiliaries and accessories shall be capable of performing intended duties under specified conditions. The Contractor shall guarantee the reliability and performance of the individual equipment as well as of complete system.

17.10 Design and Construction

17.10.1 Standards

The system and equipment shall be designed, built, tested and installed to the latest revisions of the following applicable standards. In the event of other standards being applicable they will be compared for specific requirement and specifically approved during detailed engineering for the purpose:

Sl. No.	Standard	Description
1	-	ASHRAE Handbook, data and guidebook
2	IS 4720	Code for practice for ventilation of surface
3	IS 3103	Code of practice for industrial ventilation
4	ANSI/ ASHRAE Standard 62	Ventilation for acceptable indoor air quality

5	IS 655	Specification for metal air duct
6	IS 277	Galvanized steel sheets specification

All equipment items shall be designed to operate at the rated characteristics of the installation in continuous mode. The system shall allow maintenance of various system elements without affecting service continuity. The ambient conditions, moisture, temperature and seismicity shall be taken into account for the design, operation and installation of the equipment.

Generally, the equipment construction shall be according to current Indian or International rules and standards.

17.10.2 Air Handling Units

17.10.2.1 General Description

Unit shall be central station air handler. It shall consist of a fan with the following factory-installed components as indicated on the equipment schedule, as per applicability

i) Cooling coil section with chilled water coil

ii) Heating coil section with electric coil

iii) Access and plenum section.

iv) Filter section

v) Mixing box section:

vi) Face and bypass damper sections for:

a) Multi zone damper section.

b) Air mixer section.

c) Return fan section.

d) Exhaust section.

Units shall ship in the number of sections necessary to meet project requirements. All sections shall be flanged and gasketed to allow easy assembly and disassembly.

17.10.2.2 Casing

i) Construction

The AHUs shall be double skinned free floor standing type, constructed as a stable compact galvanized steel casing, factory assembled, divided in several cubicles for easier installation.

a) Casing panels shall be removable for easy access to unit. All panels shall be gasketed to ensure a tight seal.

b) The construction of the AHU shall allow for easy maintenance/replacement of faulty components without dismantling the whole assembly

c) Access sections shall have a double-wall hinged access door on both sides of component.

ii) Insulation

Each section shall be factory insulated. Insulation shall have full coverage waterproof adhesive to firmly secure the material to the unit casing. Insulation shall meet the erosion requirements of UL 181. Insulation and insulation adhesive shall comply with NFPA 90A requirements for flame spread and smoke generation.

iii) Drain Pans

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Drain pans shall be constructed of insulated double wall stainless steel. The pan shall be sloped toward the drain fitting.

17.10.2.3 Fans

Forward-curved fans shall have one double width double inlet (DWDI) fan wheel and scroll. They shall be constructed of heavy gauge galvanized steel. They shall be designed for continuous operation at the maximum rated fan speed and motor horsepower.

Air foil fan sections shall have one DWDI air foil fan wheel and scroll. Air foil blades shall be double thickness design. They shall be painted with zinc chromate primer and enamel paint.

Plenum fan sections shall have one single width single inlet (SWSI) air foil fan wheel. Air foil blades shall be double thickness design. Wheels shall be painted with zinc chromate primer and enamel paint. They shall be designed for continuous operation at the maximum rated fan speed and motor horsepower.

All fans bearings shall have a minimum life of 40,000 hours. Fan shafts shall be solid steel, turned, ground, polished and coated with rust preventative oil. All fan motors shall have minimum service factor of 1.15.

17.10.2.4 Filter Sections

Flat filter sections shall accept 25, 50,100MM (1-in,2-in., or 4-in.) width filters in any combination that totals 25, 50, 75,100MM (1, 2,3OR 4 inches).

17.10.2.5 Dampers

Mixing boxes, filter-mixing boxes, and exhaust boxes shall have parallel blades and interconnecting outside-air and return-air dampers. Damper blades shall be constructed of galvanized steel with a double skin airfoil design.

17.10.2.6 Air Mixer

Air mixer shall be constructed of welded aluminium framing and turbulators. The mixer shall have no moving parts. It shall contain a primary set of direction-changing vanes, a secondary set of turbulator vanes, and a cone design for mixing of air streams.

17.10.2.7 Coils

i) General Fabrications

a) All water and refrigerant coils shall have 12.5 mm OD seamless copper tubes mechanically expanded into fins to ensure high thermal performance with lower total flow and pumping requirements. Minimum tube wall thickness shall be 0.6mm.

b) Copper plate fin type with belled collars. Copper finned coils shall be supplied with stainless steel casing and tube sheets

ii) Water Cooling Coils

Headers shall be non-ferrous with steel MPT connections.

iii) Refrigerant Coils

Headers shall be seamless copper tubes with brazed joints.

iv) Electric Heating Section

Electric heating sections shall be constructed of pre painted galvanized steel and shall provide mounting of the heater control box access door on the side of the unit. The manufacturer shall furnish an integral control box. It shall contain thermal cut-outs, primary and secondary control, sub-circuit fusing, airflow switch, and fused control transformer.

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17.10.2.8 Humidifier

AHU's shall be provided with Humidifier, Pan Type steam boiler (if required), to raise and maintain specified level of indoor Relative Humidity (RH). The Humidifier will consist of insulted Pan, electric heater, water connection and wiring.

Accessories will include float switch for low water level cut-out, float valve with stainless steel ball, thermostat, sight glass and humidistat for sensing/controlling humidity.

It will be duly factory wired (control as well as power) with copper bus bar connection and terminal box. The pan will be thermally insulated. In addition to providing heating element of required rating, as specified, the humidifier will be provided with 0.5 KW heater with thermostat to maintain water temperature.

17.10.3 Blowers/Boosters

Blowers/boosters shall consist of fans, casings, air filters and dampers with enclosures. The fans, casings, air filters and dampers shall be as per relevant sub clauses of Air handling unit of this section.

17.10.4 Air Cooled Chiller Unit (ACC)

The packaged Air cooled chiller will consist of accessible, hermetic direct driven centrifugal compressor with independent circuits evaporator, condenser, microprocessor based control and a unit-mounted motor starter, refrigerant charged, factory run-tested and ready for operation.

17.10.4.1 Compressor

The compressor will be proven design for use with ozone friendly refrigerant (HFC-134a). The specification shall be subject to Employer's approval.

The design of the compressor should ensure vibration-free operation over a wide range of operating conditions and high energy-efficiency. The capacity controlling device shall be arranged for unloaded start. Power consumption shall proportionately reduce with the stepping down of compressor capacity to as low as 25% of full load in direct response to refrigeration load changes.

17.10.4.2 Compressor Motor Assembly

The compressor will have, accessible hermetic direct drive motor with 2950 rpm (or as per manufacturer's design speed), working on 415V ± 10%, 3 phase, 50 Hz ± 5%, power supply. The motor will be squirrel-cage two-pole induction type and will be suction-gas-cooled. Due consideration will be given while deciding the protection devices to take care of probable voltage fluctuations prevailing at site.

Rolling element-bearing groups will be provided at each end of both rotors, separately housed, and pressure lubricated. The system will be provided with oil separator and filtration devices.

17.10.4.3 Condenser

Condenser coil shall be water cooled with integral sub-cooler constructed of aluminium fins mechanically bonded to seamless copper tubes, which shall be then cleaned, dehydrated and sealed. Air-cooled condenser coil shall be leak tested at 10 KG/sq. cm (150 PSIG).

17.10.4.4 Chiller (Cooler)

Chillers shall be direct expansion/ flooded type comprising mild steel shell, integrally finned copper tubes rolled into tube sheets cast iron water heaters, liquid line connection, suction header, drain plug and purge valves. Shell and tube type chillers shall have the following components:

i) Shell and Water Boxes

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The chiller shell shall be formed of carbon steel, provided with cast iron water boxes having standard flange type connections suitable for 10KG. Per sq. cm (150 psig) working pressure. Water boxes shall be provided with drain connections and shall be easily openable for tube cleaning. Suitable tapping shall be provided in the water boxes/ water lines for temperature control bulb and gages

ii) Tubes

12.5 to 19 mm diameter seamless copper tubing shall be used for evaporator surface. Each tube shall be individually replaceable.

iii) Insulation

The chiller shell shall be covered with expanded polystyrene in multiple layer of thermal insulation with vapour barrier as per the section "Insulation". Suction line of refrigerant circuit piping shall also be provided with thermal insulation.

17.10.4.5 Refrigerant Piping and Components

Refrigerant piping and fittings inter connecting compressor, condenser and chiller shall be all copper and valves shall be brass/ gunmetal construction.

Refrigerant circuit components shall include hot gas muffler, high side pressure switch, liquid line shut off valves, filter drier moisture-indicting sight glass, stepper motor actuated electronic expansion valve or thermostatic expansion valve, and complete operating charge of refrigerant and compressor oil.

17.10.5 Controls

17.10.5.1 Unit Control Module

i) The unit shall be provided with microprocessor control system for Air cooled centrifugal chiller with latest chiller control technology.

ii) It shall have control logic with the Clear Language Display, which will have various functions that allow the operator to read unit information and adjust set points.

iii) Equal Compressor Sequencing - The control system shall maximize both compressor and motor life by equalizing the number of starts and the operating hours. The UCM will start the compressor with the least number of starts and turn off the compressor with the most operating hours, equalizing starts and running hours. This will provide equal compressor wear to various units.

iv) Chiller Flow Protection - The in-built protection will automatically detect a no water flow condition.

v) Chiller System Logging: -

vi) The UCM will display data required to log the chiller system. The following information will be available as standard feature with the water-cooled centrifugal chiller Microprocessor:

a) Entering and leaving chilled water temperatures,

b) Ambient air temperature,

c) Evaporator and condenser refrigerant temperatures and pressures,

d) Percent RLA for each compressor,

e) Percent line voltage,

f) Compressor starts and running hours,

g) Active set points:

- Chilled water set point

- Current limit set point
- Low ambient lockout set point

h) Over 90 diagnostic and operating conditions

i) Part failure diagnostics:

- Water temperature sensors
- Refrigerant temperature sensor
- Compressor contactors

j) Interface to the Station SCADA system

vii) The system should have provisions and facility for interfacing the chiller with plant SCADA System:

a) Chiller Inputs will Include

- Chiller enable/ disable
- Circuit enable/ disable
- Chilled water set point
- Current limit set point

b) Chiller Input will Include

- Compressor running indication
- Alarm indication (for each circuit)
- Maximum capacity

c) Chilled Water Pumps will Include

- Remote/local selector switch,
- Start/stop push buttons
- Pump operation sequencing for equal running hours of pumps and change over in case of electrical/hydraulic fault.

17.10.6 Piping and Valves

The necessary piping installation for:

i) Chilled water circuit to all cooling coils.

ii) Condense water discharge from all above-mentioned air coolers shall be included in the supply. The supply shall also include the necessary fittings, valves (manually and motor operated valves, return valves etc.), flow control meters, pressure gauges, thermostats, insulations and fixations. All embedded and exposed pipes size 25mm and above shall be galvanized and insulated of minimum schedule 40. Pipes sizes less than 25mm shall be minimum schedule 80. Gravity drain pipes shall be of minimum schedule 20. The piping and valves shall be in accordance with clause no. 5.7 “Piping, fittings, valves and Heat exchangers” of “General Technical Specification (GTS)”. Valve body of all type of valves shall preferable be of cast steel except smaller valves (50 mm and lower) for which the material shall be stainless steel.

17.10.7 Cooling Water System

17.10.7.1 Chilled Water Pumps

The chilled water pumps shall be horizontal centrifugal type. The material of the pump impeller shall preferably be high grade duplex stainless steel (AISI 329 or better). The selected

impeller material shall have excellent abrasion and corrosion resistant properties. Shaft and casing material shall be stainless steel (AISI 420 or better) and grey cast iron respectively.

The pumps shall be complete with continuous duty electric motors with class F insulation (temperature rise limited to class B), control panels, cables, anchor bolts and other mounting materials complying with suitable Indian and International Standards. The motor shall be suitably sized to drive the pump continuously over the specified characteristics without getting overloaded. The pumps shall be suitable for 415V ± 10%, 50Hz ± 5% with contacts for remote operation / indication. The speed of pumps shall preferably be not more than 1500 rpm.

Shut-off valves and check valves shall be provided to allow disconnection and switching of each pump without emptying pipes.

17.10.7.2 Automatic Self Cleaning Filters

The automatic self cleaning filters shall be of sufficient capacity to match the capacity of the cooling/chilled water pumps. The equipment must have proven performance in treating water with high abrasive silt content. The automatic self cleaning filter shall be heavy duty preferably wedge wire candle type to arrest debris, tree leaves, pebbles, coarse sand etc. The filter shall comprise of stainless steel candles and shall have cast steel body. Automatic filters shall be capable of removing all the material of 500 microns and above size in raw water circuit and 100 microns and above in chilled water and secondary cooling water circuit. The design shall have proven performance for continuous operation without clogging. The pressure drops across the filters shall be less than approximately 0.2 bars.

Differential pressure gauges and differential pressure switches across each filter shall be provided with visual indication for alarm purpose. The silt flushing operation shall be controlled/ initiated by both pressure difference and pre set time.

17.10.7.3 Automatic Self Cleaning Filters

A separate make up water tank/expansion tank for closed loop chilled water circulation pumps shall be provided. The tank shall be provided with an automatic filling valve in the filling line including level switch, level gauge and level transducer for local and remote alarm/ indication. All other required instrumentation, connections etc. as required, shall also be provided.

17.10.8 Ducts

All ducts for the ventilating and air conditioning systems shall be of high quality galvanized sheet metal (GSS). The exhaust air ducts of the battery room shall be corrosion, rust and acid resistant material. Ducts passing through the machine hall and service bay shall maintain the aesthetic of the floors and shall be finalised during detailed engineering.

The sheet thickness shall not be less than the thickness indicated in the table below. The thickness shall depend on the length of the longer side of the duct:

Up to 450mm - 0.80mm

From 451mm to 1200mm - 1.0mm

Over 1200 - 1.2mm

All ducts shall be airtight with opening at suitable locations. If necessary, the rectangular elbows shall be equipped with aerodynamically formed guiding vanes.

All take-off branches shall be equipped with an adjustable volume extractor, which assists in balancing by directing a regulated amount of air for supply outlets from the main duct. Volume dampers shall be two gauges heavier than gauge of the large duct and shall be rigid in construction to the passage of air.

Ducts shall be supported by structural angles, hanging in rods with adjustable nuts, anchored to the ceiling or walls by concrete fastener bolts or anchors. The material for all support, hanger, rods, angle etc shall be hot dip galvanised. Maximum allowable distance between duct supports is 1500 mm

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17.10.9 Insulations

The cooled down supply air ducts shall be insulated to prevent condensation on the duct surfaces.

The insulation material (thickness to be as per detailed design) shall be non-hygroscopic, rot-proof, preferably of mineral raw material such as rock wool. The insulation mats or plates shall be fastened on the duct and wrapped with aluminium foils. The insulation material shall be also sufficient to obtain the acoustical guarantee.

The chilled and cooling water piping shall be properly insulated. The mentioned insulations shall be included in the supply.

17.10.10 Grills and Diffusers

The supply air grills shall be used for correct air distribution by horizontal and vertical adjustable bars of sidewall installations. The return air grills shall be suitable for adjustment from outside and shall be equipped with 45° horizontal fixed fins.

The grills / diffusers in the control rooms / offices and other areas where false sealing have been provided shall be decorative type and in accordance to the architecture of the control room and conference room and aesthetic of the area. Material of construction, type colour etc. shall be decided during detailed engineering.

The design has to fit the architectural false ceiling and lighting schemes and the grills be made of extruded aluminium powder coated with high surface finish and the sizes have to correspond to the fixed noise criteria.

Grills for the battery room shall be of acid corrosion and rust resistant material.

17.10.11 Outside Air Louvers

Outside air louvers of each of the fresh air and exhaust air systems shall prevent the entrance of rain, insects, birds and trash into the ducts.

They shall be stamped and pressed out of one piece of aluminium sheet of at least 2 mm thickness. The frames shall also be made of extruded aluminium.

17.10.12 Louver Dampers

Double acting louvers shall be fabricated with a welded frame of rolled section. Bearings shall be of the oil retaining porous bronze type and shall be fixed into the frame.

The louver dampers as well as the steel frames shall be hot dip galvanized after fabrication. Louvers and dampers shall be equipped with related limit switches to be used in control and interlocking system.

The fire /smoke dampers shall be provided wherever required. The damper shall be multi blade motorized operated type. The blades shall be minimum 1.6 mm thick aluminium. The frame shall be minimum 2 mm thickness.

17.10.13 Air Filters

The filters shall be of the viscous impingement type, cleanable, aluminium wire mesh coated with viscous substance such as filter oil or grease. Separation degree may be similar to EU4 (rough air filter), according to EUROVENT or DIN 24185 standards. The frame structure of the panel cells shall be made of aluminium sections.

A properly positioned pressure gauge of the inclined tube type shall give an indication of the degree of dust loading on the filters for establishing the periods between services.

17.10.14 Exhaust Air Fans

Exhaust air fans shall be adjustable axial flow fans. Axial air fans shall be of the multi blade vane type. The vanes shall be adjustable individually at standstill. The hub of the impeller shall

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be directly coupled to the motor shaft and its diameter adapted to the motor frame. The impeller shall be statically and dynamically balanced.

All bearings shall be pre-lubricated, self-aligning and selected for a minimum of 40000 hour's average life at the maximum design rating. If, however, frequent lubrication is required this should be possible from the outside of the fan casing without disturbing the fan duct assembly. Bearing supports shall be specially designed for trouble-free bearing service. All fan shafts and wheels shall be designed to operate at their maximum rated speed, which is below the first critical speed.

All motor bases shall be adjustable and V-belt drives selected for 120 percent of motor power. The steel casing of the air fans shall be made of hot-dip galvanized steel or aluminium. Where the impeller is accessible in operation, guards shall prevent injuries to maintenance personnel. Antivibration mountings shall be provided for each fan.

17.10.15 Bolts, Nuts and Washers

All bolts, screws and nuts shall be of metric thread standards and have hexagonal heads. The material shall be of stainless steel.

17.10.16 Controls and Electrical Equipment

The HVAC system shall be equipped with operation on fully automatic mode and manual mode. All the necessary cabling between the control panels and the field HVAC components (as fans, sensors, pumps, valves, air dampers, etc.) shall be included in the supply

Each of the control systems shall be equipped with the necessary control, interlocking and security devices. Any failure or breakdown in the control system shall be indicated by a signal on the respective control panel, as well as remotely in the main control room. Potential free contacts and terminals for remote indication of the alarms shall be provided in the panels. All necessary protection viz. single phasing, IDMT and Instantaneous over current relays, under voltage relays etc. shall be provided.

Pumps shall be provided with electric motors, anchor bolts and other mounting materials. The pumps shall be with starting unit suitable for 415V ±10%, 50Hz ± 5% with contacts for remote operation / indication.

17.10.16.1 Automatic Control and Regulation

i) The HVAC system shall be equipped with a fully independent computerized automatic control system for efficient operation, which shall be included in the supply. It should automatically stop the supply of fresh / re-circulated air to the affected zone immediately in case of fire detection and initiate smoke extraction.

ii) All sensors and instruments (temperature, pressure, humidity, etc.), limit switches, etc. required for automatic regulation and monitoring of proper service of the systems shall be included in the supply.

17.10.16.2 Manual Mode

Individual starting and stopping of equipment's by push buttons.

17.11 Drawings, Documents and Design Calculations

17.11.1 Design memorandum

The Contractor shall submit to Employer a design memorandum prepared the Design basis of HVAC system.

17.11.2 Drawings and documents

The Contractor shall submit all the drawings and documents to Employer to get the Approvals.

17.11.3 Design Calculations

The Contractor shall submit the design calculation for approval.

i) Sizing of ducts for air distribution,

ii) Calculation for selecting the Blowers, AHUs and other fans capacity,

iii) Calculation for selecting the chiller capacity,

iv) Cooling loads, Heating loads, air flow rate and temperature and humidity conditions at all locations/areas,

v) Calculation for selection of chilled water pumps and motors.

The Contractor shall also provide other calculations as required by the Employer for his approval of the Contractor's design.

17.12 Test, Delivery, Installation and Commissioning

17.12.1 Shop Tests

The Chiller units, Blowers, Filters, Motors, Fans, Dampers, valves, Grills, Pumps, Tubes, Duct material and Pipes etc. shall be routine tested as per relevant IEC/IS and international code for HVAC. The contractor is required to submit routine test certificates of the equipment. Copies of the type test certificates in respect of the similar equipment supplied in the past for hydro projects would also need to be supplied.

17.12.2 Field Tests

The Contractor shall follow the requirements of Delivery, Installation and commissioning elaborated in the Volume 1.

17.12.3 Field Tests

After installation, HVAC systems shall be field tested for operational tests as per the intended requirements and leakage tested. If the system shall be tested in sections, the same applies for each section.

All necessary materials and labour for performing the entire required test shall be provided by the contractor.

The contractor shall prepare and hand over to the Employer details of all test results in a report in a mutually agreed format.

17.12.4 Installation & Commissioning

The contractor shall furnish all labour, supervision, tools, supplies, bracing, spiders, shims and supports and all other provisions or materials necessary to assemble, erect, install, test and commission the equipment in a thorough workman like manner following the best modern practices. The equipment and all its components shall be placed with great care and accuracy and shall be aligned correctly to provide an installation consistent with the close tolerances used in the erection of modern equipment.

The proper elevations and centerlines to which equipment is to be set shall be established by the contractor.

All installation of Chiller units, AHU's, Pumps, Ducting and Complete system shall be done by skilled workers in a workmanlike manner. Pipe fixtures shall be spaced according to accepted standards and provision made for thermal expansion and contraction of piping. Before installation all system components shall be checked for cleanliness.

17.13 Schedule of Requirement

The scope of supplies and services shall be as per various clauses of the technical specifications and supplier shall be responsible to ensure completeness of supplies and services even if these are not fully covered under this clause.

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Any item of supply not explicitly listed but otherwise implied by the contents of the specification or essential for smooth operation of the equipment shall be construed as forming part of the supply and no additional charges shall be payable for the same.

The broad schedule of requirements is given in clause 15.1.1 "Scope of Work".

17.14 Spare Parts

Recommended spare parts shall be supplied in accordance to clause 3 "Spare Parts and Tools" of General Technical Specifications. Specified spare parts to be supplied under this Chapter are as follows.

Sl. No	Description	Unit	Quantity
1	Motor Bearing	no. of each type	1
2	Safety valves	no. of each type	1
3	Pressure gauge, pressure switch and pressure transducer	no. of each type	1
4	Temperature gauge and temperature switch	no. of each type	1
5	Filter element	no. of each type	2
6	Air Grills	no. of each type	2
7	Pump Impellers	no. of each type	2
8	Pipes & Tubes	RMT each type	2
9	Solenoid and directional valve	no. of each type	1
10	Standard gasket/ O- ring/packing kit for compressor	nos.	4
11	Valves DN15 and above	no. of each type	2
12	Belts	no. of each type	2
13	expansion valve	nos.	2
14	Motors	no. of each type	1

Besides above, the Contractor shall recommend any additional spare parts, which in his opinion are necessary for satisfactory operation of the system. However, the procurement of these recommended spares shall be at the discretion of the purchaser. The additional recommended spare parts shall be indicated in the Data Sheets of Volume-6.

17.15 Guaranteed & Other Technical Particulars

The Contractor shall follow the Guaranteed & Other Technical Particular requirements specified separately in Technical Data Sheets.

17.16 Tools and Instruments

The Contractor shall supply all necessary tools and Instruments etc. for installation, repair and maintenance in accordance to clause 3.2 "Tools and Instruments" of General Technical Specifications.

17.16.1 Special Tools

The Contractor shall list and supply all special tools. List of such tools including their make and detailed specification, shall be submitted for acceptance by the employer.

17.17 Deputation of Engineers for witness of Tests, Inspection & Training

The Employer's representatives shall be deputed for the following purposes.

Sl. No.	Description	Batch	No of Days	No. of Engineers and Technicians
1	Training at the plant and design office	1	3	2 Engineers 4 Technicians

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2	Shop Inspection and Test	As and when required for inspection and test

The training of employer's personnel shall be as specified in clause 11.0 "Training of Employer's Personnel" of General Technical Specification.

17.18 Deviations from Specifications

All deviations from these specifications shall be separately listed in the requisite Performa of the bid document, in the absence of which, it will be presumed that the provisions of the specifications are fully complied with by the bidder. However, the deviations, which are better than the specifications shall be considered by the purchaser.

17.19 Completeness of Contract

Any fittings, accessories or apparatus required for successful commissioning though may not have been specifically mentioned in the specification but are usually necessary for the completeness of the works shall be deemed to be included in the specification and shall be supplied by the bidder without any extra cost to the purchase

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17.20 Employer's Specifications

Sl. No.	Item	Units	
1	**General**		
1.1	Designation		Air distribution system
i)	Air conditioning system		YES
ii)	Normal ventilation system		YES
iii)	Fire & smoke system		YES
iv)	Fume extraction system		YES
1.2	Duct construction method		SMACNA / IS 655 /
1.3	Ducting shape		Rectangular/Round/Spiral/Oval
1.4	Type of fabrication		Factory / Site Fabricated
1.5	Ducting sheet material		GSS
1.6	Pre-insulated duct		YES
1.7	Flexible duct		YES
1.8	Fire rated duct		YES
1.9	GSS ducting class		VI / VII / VIII
2	**Diffusers**		
2.1	Supply air diffuser with damper		YES / NO
i)	Shape		SQUARE
ii)	Type		FLUSH
iii)	Material		MS Epoxy Painted / AL Powder Coated / SS 304
2.2	Return air diffuser without damper		YES / NO
i)	Shape		SQUARE
ii)	Type		FLUSH
iii)	Material		MS Epoxy Painted / AL Powder Coated / SS 304
2.3	Linear slot diffuser with hit & miss damper		YES / NO
i)	Number Of Slots		1 / 2 / 3 / 4 / 6
ii)	Material		MS Epoxy Painted / AL Powder Coated / SS 304
iii)	Air Plenum With Damper		YES / NO
2.4	Jet Diffuser		YES / NO
i)	Material		MS Epoxy Painted / AL Powder Coated / SS 304
2.5	Swirl Diffusers		YES / NO

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Sl. No.	Item	Units	
i)	Material		MS Epoxy Painted / AL Powder Coated / SS 304
3	**Grilles**		
3.1	Supply Air Grilles With Damper		YES
i)	Shape		Square / Rectangular / Linear
ii)	Material		AL Powder Coated / SS 304
iii)	Type		Single Acting / Double Acting
3.2	Supply Air Grilles Without Damper		YES
i)	Shape		Square / Rectangular / Linear
ii)	Material		MS Epoxy Painted / AL Powder Coated / SS 304
iii)	Type		FIXED BLADE
4	**Dampers**		
4.1	Volume Control Damper		
i)	Blade Type		Aerofoil / Parallel / Opposed / Single
ii)	Shape		Rectangular / Round
iii)	Material		GSS / AL / SS 304
iv)	Casing Sheet Thickness		16G / 18G
v)	Blade Thickness		18G / 20G
vi)	Flange Width	mm	25 / 30 / 40
4.2	Back Draft Damper		YES / NO
i)	Shape		Rectangular / Round
ii)	Material		GSS / AL / SS 304
iii)	Casing Sheet Thickness		18G
iv)	Blade Thickness		20G / 24G / 26G
4.3	Pressure Relief Damper		YES / NO
i)	Shape		Rectangular / Round
ii)	Material		GSS / AL / SS 304
iii)	Casing Sheet Thickness		16G / 18G
iv)	Blade Thickness		18G / 20G
v)	Counter-Weights Option		YES / NO
4.4	Mechanical Fire Damper		YES
i)	Shape		Rectangular / Round
ii)	Material		GSS / SS 304

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Sl. No.	Item	Units	
iii)	Thickness		16G / 20G FOR CASING AND 16G FOR BLADES
iv)	Fusible Link		UL 555 STAMPED
v)	Fusible Link Temperature Rating	°C	70 / 74
vi)	Required Fire Rating Time	MIN.	90 / 120 / 180
vii)	400mm EXTENDED SLEEVE DUCT ON EITHER SIDE		YES / NO
4.5	Motorized Fire Damper		YES / NO
i)	Shape		Rectangular / Round
ii)	Material		GSS / SS 304
iii)	Thickness		16G / 20G FOR CASING AND 16G FOR BLADES
iv)	Damper Listing		UL 555
v)	Power Supply		230V / 24V (AC / DC)
vi)	Control Panel Required		YES / NO
vii)	Actuator Enclosure & Cable		NORMAL / FLAMEPROOF
viii)	Required Fire Rating Time	min	90 / 120
4.6	Fire And Smoke Damper		YES / NO
i)	Shape		Rectangular / Round
ii)	Material		GSS / SS 304
iii)	Thickness		16G FOR CASING AND BLADES
iv)	Damper Listing		UL 555S
v)	Power Supply		230V / 24V (AC / DC)
vi)	Control Panel Required		YES / NO
vii)	Actuator Enclosure & Cable		Normal / Flameproof
viii)	Duct Smoke Detector		Required / Not Required
ix)	Required Fire Rating Time	MIN.	90 / 120
4.7	Blast Damper		YES / NO
5	Miscellaneous		
5.1	Kitchen Hood		NO
i)	Material		SS 304 / AL / GSS
ii)	Thickness	mm	1.4 / 1.6 / 2.0 /
iii)	Filters Type		Metallic Grease Trap
iv)	Insulation Material		Rockwool / Mineral Wool

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Sl. No.	Item	Units	
5.2	Air Plenums		YES / NO
i)	Type		Single Skin / Double Skin
ii)	Insulation		Thermal / Acoustic / None
iii)	Fabrication		Factory / Site Fabricated
iv)	Materials For Double Skin		24G Plain Sheet Outer Skin & 24G Perforated Sheet Inner Skin With Insulation Sandwiched
v)	Materials For Single Skin		18G PLAIN SHEET WITH ACOUSTIC INSULATION
5.3	Jet Nozzel		YES / NO
	Material		ALUMINIUM
5.4	Disc Valve		YES / NO
i)	Material		GSS
6.0	**Insulation**		
6.1	Thermal Insulation Required		YES / NO
i)	Material		Closed Cell Nitrile Rubber / Mineral Wool / Rockwool / PUF / EPS
ii)	Density	kg/m³	48
iii)	Thickness	mm	25
6.2	Acoustic Insulation Required		YES / NO
i)	Material		Open Cell Nitrile Rubber / Mineral Wool With PERF. Sheet
ii)	Perforation Sheet		26G
iii)	Density	kg/m³	
iv)	Thickness	mm	
6.3	Companion Specifications		
7	**Miscellaneous**		
7.1	Duct Flexible Connections		YES / NO
i)	Material		Fire Retardant Canvas
7.2	Access Doors For Fire Dampers		YES / NO
	Size	mm	X
7.3	Sleeves For Fire Dampers		YES / NO
i)	Thickness Of Sleeve Sheet		16G
ii)	Length Of The Sleeves	mm	450 / 600
7.4	Type Of Duct Supports		Formed Sections / Rod Hangers / Wire Hangers

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Sl. No.	Item	Units	
7.5	Duct Reinforcement		Formed Sections /
7.6	Fire Painting		YES / NO
i)	Duct		Required / Not Required Red Oxide Primer, Epoxy Or Enamel (If Required)
ii)	Duct Supports		Red Oxide Primer, Epoxy Or Enamel / Galvanized
iii)	Duct Reinforcement		
7.7	Return Air Boxing		YES / NO
i)	Boxing Material		GYPSUM BOARD / POP / WOODEN
7.8	Duct Sealant		MASTIC / SILICONE / RTV SILICONE
7.9	Frame-Work For Grilles, Diffusers		TEAK WOOD / CS / AL / SS (BY PURCHASER / CONTRACTOR)
8	**Tests and inspection**		
8.1	Duct leakage testing required		YES / NO
8.2	Method of testing		SMOKE / PNEUMATIC
8.3	Maximum leakage permissible	%	AS PER DW 142
8.4	Duct support qualification for seismic forces		YES / NO

NOTES:
1. * - BY BIDDER
2. The codes and standards mentioned in the various specifications and requirements specified in the enquiry document shall be latest as on the day of award of contract of the works unless otherwise specified. Contractor shall be responsible to inform to the consultant / owner in case of any revision / re-affirmation / amendment in the relevant codes and standards after the date of award of contract within 30 days of the issue of such revision / re-affirm/amendment of the code / standard. Consultant / owner may approve use of the earlier code / standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed.

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NOTES

For stainless steel equipment, piping and duct surfaces insulation adhesive shall be mas 83 and vapour barrier shall be alf or mas 130

Insulation thicknesses in mm for insulation materials

EP, LRG and PSG

Operating TEMP. °C → Pipe Size \mm NB ↓	AMB. TO 20	19 TO 10	9 TO 0	-1 TO -10	-11 TO -20	-21 TO -30	-31 TO -40	-41 TO -50	-51 TO -60	-61 TO -70	-71 TO -80
15	25	25	40	50	50	65	75	100	100	125	150
20	25	25	40	50	50	75	75	100	100	125	150
25	25	25	40	50	65	75	100	100	125	125	150
40	25	40	50	65	75	100	100	100	125	125	150
50	25	40	50	65	75	100	100	100	125	150	175
65	40	40	50	75	75	100	100	125	125	150	175
80	40	40	50	75	75	100	100	125	125	150	175
100	40	50	50	75	100	100	125	125	150	150	175
125	50	50	50	75	100	100	125	150	150	175	200
150	50	50	75	75	100	125	125	150	150	175	200
200 and above and flat surfaces	50	65	100	125	150	175	200	200	225	250	275

NOTES

Insulation thicknesses specified do not include thickness of finishing materials such as cement sand plaster, aluminium or gs sheet, binding and lacing wires, wire netting and bands etc.
For insulation thickness for tail end air-conditioning duct and evaporative cooling system etc. Refer specification of the enquiry document.

Insulation thicknesses in mm for insulation materials

PUR, PIR and PF

Operating TEMP. °C → Pipe Size MmNB ↓	AMB.TO 20	19 TO 10	9 TO 0	-1 TO -10	-11 TO -20	-21 TO -30	-31 TO -40	-41 TO -50	-51 TO -60	-61 TO -70	-71 TO -80
15	20	20	30	40	40	50	65	75	75	100	125
20	20	20	30	40	40	65	65	75	75	100	125
25	20	20	30	40	50	65	75	75	100	100	125
40	20	30	40	50	65	75	75	75	100	100	125
50	20	30	40	50	65	75	75	75	100	125	150
65	30	30	40	65	65	75	75	100	100	125	150
80	30	30	40	65	65	75	75	100	100	125	150
100	30	40	40	65	75	75	100	100	125	125	150
125	40	40	40	65	75	75	100	125	125	150	175
150	40	40	65	65	75	100	100	125	125	150	175
200 and above and flat surfaces	40	50	75	100	125	150	150	150	175	200	225

Notes

1. **Insulation thicknesses specified do not include thickness of finishing materials such as cement sand plaster, aluminium or gs sheet, binding and lacing wires, wire netting and bands etc**
2. **For insulation thickness for tail end air-conditioning duct and evaporative cooling system etc. Refer section-c of the enquiry document**

CHAPTER-18: CABLES & CABLING SYSTEM

18.1 Scope of Work

This Specification covers the requirements of sizing, design, engineering, material selection, constructional features, manufacture, inspection and testing at the VENDOR'S or his SUB-VENDOR'S Works, delivery to Site including transit insurance, installation, testing & commissioning and performance testing of the cables, cable carrier system (Cable tray support angles, cable trays, conduits, etc.) for the power plant. The scope of work shall also include supply and installation of cable glands, cable lugs, cable termination kits, cable jointing kits, cable clamps, cable ties, cable identification tags, and cable route markers etc. for all cables supplied under this contract. All the HT/LT Power, Control & Instrumentation cables required for the entire plant shall be included in the scope.

All control, instrumentation cable sizes, no of cores, etc shall be as required for the application. Bidder shall indicate sizes, quantities of all the cables considered conforming adequacy of the same for the complete plant.

The bidder shall carefully calculate the cable lengths based on the drawings (General arrangement drawings, plot plan & single line diagram) issued with the bid document and by making the site visits. No extra claims in this regard would be entertained during the Contract execution even there is change in layout).

18.2 Codes & Standards

The codes and standards mentioned in the various specifications and requirements specified in the enquiry document shall be latest as on the day of award of contract of the works unless otherwise specified. Contractor shall be responsible to inform to the Consultant/ Owner in case of any revisions/reaffirm/amendment in the relevant codes and standards after the date of award of contract within 30 days of the issue of such revision/re-affirm/amendment of the code/ standard. Consultant/ Owner may approve use of the earlier code/ standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed.

18.3 Cable Types

The following cables will also be provided as per requirement in the project.

i) 11 kV Cables- cables will be required to connect the Station Service Transformers to 11kV switchgear. These cables will be of the Copper, XLPE type.

ii) 33 kV Cables- cables will be required to connect the 132/33kV Auxiliary Transformers to 33kV switchgear. These cables will be of the Copper, XLPE type.

iii) 415 V power cables. These cables will be required for station auxiliaries and unit auxiliaries and will be FRLS, PVC type 1.1 kV grade cables. Upto 16 sq.mm cables, Copper conductor shall be used and above 16 sq.mm cables, Aluminium conductor shall be used for LT power cables.

For DC all cables shall be of Copper conductor irrespective of its size. The cables used for DC system are of single core type. Only single core cables will be used between batteries / battery chargers and Control Cables. These will be FRLS, PVC type, 1.1 kV grade cables. They will be copper conductor cables of different cross-sections and different cores for AC/DC supply for carrying current for protection and controls.

Optical fibre cables. An optical fibre cable link will be provided between the dam and the powerhouse for transmission of data and for voice communication.

All HT cables with following specification shall be provided.

All HT cables shall be of unearthed grade single core/three core stranded aluminium conductor grade H4, class 2 as per IS 8130, screened by extruded semi conducting compound, cross linked

polyethylene insulated, cores screened with non-magnetic metallic tape helically applied single layer of copper tape, laid up, inner sheathed with extruded PVC compound type ST2, armoured with aluminium wire armoured for single core/Galvanised steel round wire armoured for multi core and overall sheathed with extruded FRLS PVC type.

For 415V power supply services, space heating, PVC power cables with the following specifications shall be provided.

1100 Volt grade, single or multi core, stranded aluminium conductor, XLPE insulated, cores laid up, inner sheathed with extruded PVC compound type ST2, armoured with galvanised steel wire or strip for multicore cables and aluminium wire or strip armoured for single core cables, outer sheathed with extruded FRLS PVC compound type ST2 complying with IS: 7098.

For control, protection, CT/PT connections and interlocks, metering, solenoids with signal voltages more than 60volts, PVC control cables with the following specifications shall be provided. 1100 volt grade, multi core, stranded annealed high conductivity copper conductor (class 2 as per IS 8130), extruded PVC compound type C insulated, cores identified by numerals, cores laid up, inner sheathed with extruded PVC compound type ST1, armoured with galvanised steel wire/strip and outer sheathed with extruded FRLS PVC compound type ST1 cable complying with IS:1554.

For low voltage digital and analogue signals, instrumentation cables with following specification shall be provided:

Instrumentation cable shall be twisted pair (over all shielded for digital signals and individually & over all shielded for analogue signals). For RTD 8T cable shall be supplied. Compensating cable shall be individual shielded. Instrumentation cable shall be stranded tinned, annealed, high conductivity copper conductor (class 2 as per IS 8130), extruded PVC compound type-A insulated, cores identified by colour and coding, individual pair/triplet twisted, cores wrapped by non-hygroscopic material by taping or extrusion, non-metallic rip cord under wrapping, individual pair/triplet screened with aluminium mylar tape of 0.04mm thick or copper tape of 0.04mm thick or copper laminated plastic tape with 30% overlap, provided with 0.5Sq.mm tinned copper drain wire for each cabling element, cabling elements suitably grouped, colour coded, cables overall screened with tinned copper wire braids of 0.15mm dia with minimum coverage of 85% or aluminium mylar tape of 0.04mm thick with overlap of 30%, inner sheathed with extruded PVC compound type ST1, armoured with GI wire strips/wires and outer sheathed with extruded FRLS PVC compound type ST1 complying with IEC.189-Part 1&2.

The HT & LT power cables shall be selected based on current carrying capacity, short circuit rating, permissible voltage drop and voltage dip during motor starting. The contractor shall submit the cable sizing calculation for all power cables included under this contract.

All the cables feeding switchboards from transformers shall be sized based on transformer rating. All the cables and bus ducts feeding transformers shall be sized based on current ratings of transformer at the minimum voltage tap of the transformer. All other cables shall be sized based on the load demand under most onerous conditions.

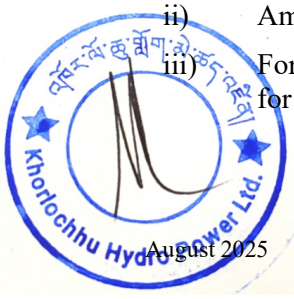
18.4 Current Carrying Capacity

The cable shall be able to carry the full load current of the circuit continuously under the specified ambient temperature and other conditions of installation. For this purpose, suitable de-rating factors shall be considered due to:

i) Thermal resistivity of soil

ii) Ambient ground / Air temperature

iii) For grouping of cables. The design ambient air temperature and ground temperature for this plant shall be considered as 50ºC and 40ºC respectively.



18.5 Short Circuit Rating

The cables for circuit breaker controlled circuits shall withstand the fault currents for a minimum time of 1.0 Sec for Incomers/ tie feeders / transformer feeders and 0.25Sec for motor feeders respectively in general.

For cables to 415V motors and feeders protected by fuses, the cross section shall be chosen according to the cut-off current of the fuse and it's fusing time.

18.6 Permissible Voltage Dip Normal Running

415V System: Voltage drop in cables between MCC to the motor terminals for full load motor current shall be limited to 3%.

18.7 Permissible Voltage Dip During Starting

415V system: The voltage drop during starting of individual 415V motors shall be limited to less than 15% of the full load voltage and 20% of the full load voltage for MV motors.

For voltage dip consideration, the starting current is taken as 6 Times of the full load current (+20% tolerance will be applied as per IS 323).

Up to 16 sq.mm cables, Copper conductor shall be used and above 16 sq.mm cables, Aluminum conductor shall be used for LT power cables. For DC all cables shall be of copper conductor irrespective of its size.

All D.C. power supply cables shall be single core cables.

18.8 Control Cables

The minimum cross-sectional area for control cables shall be 2.5Sq mm. However, for applications mentioned below 1.5Sq.mm copper conductor can be used.

Wiring of field device contacts to low burden circuits to Control and relay panels, interlock panels, local cabinets.

Current transformer leads shall be checked for lead burden, VA capacity and knee point voltage. However, the CT connection to relays minimum cross section of 4 Sq mm shall be used.

18.9 Instrumentation Cables

The cross sectional area shall be minimum 0.5 Sq.mm & shall meet the requirement system employed.

18.10 Specific Requirements of Cables

The following aspects are applicable for all types of cables.

i) Core Identification shall meet the requirement of IS.

ii) FRLS PVC compound for outer sheaths of all the cables shall meet the following performance requirements and cables shall pass these tests.

iii) The critical oxygen index values shall be minimum 29 at room temperature and the temperature index value shall be minimum 230ºC at oxygen index of 21 when tested as per ASTM-D-2863-77.

iv) The maximum total acid gas generation as determined by titration shall be less than 20% by weight, when tested as per IEC 60754-1(1994).

v) The maximum smoke density rating shall not exceed 60% when tested as per ASTM-D-2843-77.

vi) The cables shall pass the hydraulic stability and ultraviolet test as per DIN 53387. The values of tensile strength and elongation measured shall not be more than 60% of that measured before the test.

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vii) The finished cables shall pass the flammability test as per IEC-332-1 and IEE-383. In addition it shall also pass flammability test as per class F3 of Swedish Standard SS-424-1475.

viii) The cables shall be suitable for continuous operation and satisfactory performance for the following power supply conditions. Variation in supply voltage ± 10% for MV cables. Variation in supply voltage (+) 10% & (-) 15% for LV cables. Variation in supply frequency ±5%. Combined voltage and frequency variation 10%.

ix) There should not be any joint in the run of cable.

18.11 Tests

The Contractor shall conduct the routine tests on each drum length, acceptance and type test on the cables as per applicable standards. Also special tests for critical oxygen index, temperature index values, acid gas generation, smoke generation, flammability test, effects of light and water test shall be conducted on specimen, from different batches.

18.12 Cable Carrier System

Following cable carrier system shall be adopted in various areas as indicated below.

Powerhouse building / Switchgear & Control Room	: Overhead cable trays
Cable gallery	: Cable trays
GIS / Transformer area	: Trenches / Overhead cable trays
Cable carrier system connecting outlying areas	: Hume pipes/trenches/Overhead cable trays
Road /rail crossing	: Hume & steel pipes
DG house	: Cable trays / trenches
Switchyard	:Overhead cable trays / cable trenches

The contractor shall prepare detailed cable routing diagram, cable tray /trench layouts for purchaser's approval. Cable layout drawings shall indicate details of cable trenches, trays, conduits, duct banks, pipe sleeves, wall floor openings, buried cable route indicating both plan & section & bill of material. Cable schedules and interconnection schedules for all the cables, covering all the equipment supplied under this contract shall be furnished for purchaser's approval.

Cable trenches / Conduits / Pipe sleeves / duct banks etc. in the powerhouse, Requirement of cable trenches/conduits/pipe sleeves/duct bank etc with respect to size, number of trays, route etc. shall be furnished well in advance as not to hinder progress of civil work. Cable layout drawings indicating the same shall be furnished indicating in addition, all the floor/wall openings, embedment's etc. Contractor shall provide cable trays in the trenches provided by the civil contractor. However, cable trenches/conduits, duct banks/pipe sleeves etc required for the switchyard, generating transformer, transformer yard & interconnecting trenches etc from the powerhouse to various other buildings shall be constructed by this Contractor as required. Cable trays shall be erected as required.

The Cable trench walls shall be provided with insert plates for the installation of cable try support angles by the Contractor. The Contractor shall supply, install, test and commission the cables and all cable installation material in these trenches. Following the installation of cables the Contractor shall fill the cable trenches with sand. All single core cables shall be laid in trefoil formation.

18.13 Cable Trays

Cable trays of ladder and perforated types and the associated accessories such as coupler plates, tees, elbows, etc., shall be prefabricated from 2mm thick mild steel sheets, Cable tray covers shall be prefabricated from 1.7mm thick MS sheets.

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i) Depth of cable tray shall be 100 mm minimum.

ii) The spacing of rungs for ladder type of trays shall be not more than 250mm.

iii) Vertical raceways shall be formed by either structural members or slotted angles or by running the prefabricated trays vertically.

iv) Prefabricated Cable trays, accessories and covers shall be hot dip galvanised.

v) Perforated Cable trays shall have standard width of 150mm, 300mm, 450mm & 600mm and standard length of 2.5metre.

vi) Ladder type Cable trays shall have standard width of 300, 450, 600 and 750 mm and standard length of 2.5meters.

vii) Perforated types cable tray to be used for control and C&I cables only.

18.14 Conduits & Pipes

The galvanised steel conduits shall be used for sizes up to 63.5mm. The conduits shall be manufactured by electric resistance welding process and shall be hot dip galvanised. The conduits and fittings shall comply with IS: 1653, 3837, 2667.

Galvanised steel pipes shall be used for sizes from 80mm on wards. They shall be medium duty class-B type as per IS. The pipes shall be manufactured by electric resistance welding and hot dip galvanised. The pipes and fittings shall comply with IS.

Flexible steel conduits shall be manufactured with electro galvanising process. Galvanising thickness shall be minimum 75microns. The flexible conduits and their fittings shall comply with IS: 3480, 4649.

The hume pipes/RCC pipes shall comply with IS:458.

18.15 Cable / Cable Tray Supports

Cable tray supports shall be fabricated from standard steel structures of different sizes. The sizes selected shall be adequate for the weight of cables/trays encountered.

The steel members shall be cleaned thoroughly, and hot dip galvanised to minimum thickness of 75microns / painted.

18.16 Cable Carrier Installation Practice

i) Minimum level difference between two tiers of horizontal cable trays in building, trenches shall be 275mm. In vertical race ways with multi-tiers the tiers shall be located at least with 400mm intervals.

ii) In trenches width of the cable tray shall be limited to 600mm.

iii) Separate cable trays/tiers shall be provided for different voltage grade cable viz., 132kV, 33kV power, 11/0.433kV power, 415V and 240V power, control cables and instrumentation & communication cables.

iv) Cable trays shall be supported at every 1500mm interval for horizontal and 1000 mm for vertical risers.

v) Cable trays shall be welded to the mounting / carrier structures.

vi) Vertical trays (raceways) and all outdoor cable trays shall be provided with removable 16 gauge galvanised MS sheet covers.

vii) Each continuous laid out length of cable tray shall be earthed at minimum two places by MS flats of minimum size 25mmx3mm, the distance between earthing points shall not exceed 10metres

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18.17 Cable Installation

Cables to each circuit shall be laid in one continuous length. Cable jointing and splicing shall be avoided. For the Control cable jointing, weatherproof junction boxes mounted on suitable supports shall be provided. A rain canopy shall be provided protecting the weatherproof junction box.

18.18 Outdoor Cable Installation

Where cables cross roads and water, oil or sewage pipes, the cables shall be laid in hume or steel pipes. For road crossings, the pipe for the cable shall be buried at not less than 600mm. Hume pipes shall be preferred to steel pipes from the point of view of corrosion.

The cables shall be tied to tray rungs by means of 3mm dia. nylon cord at an interval of 5000mm and also at bends.

For good sealing arrangement at entry points, suitable pipe sleeves, adequate in number and of adequate sizes shall be provided in building walls / slabs for passage of cables into a building from cable trays / racks / cable trenches located outside the building.

18.19 Cables in Trays / On Racks

Different voltage grade cables shall be laid in separate trays. When trays are arranged in tiers, HV cables shall be laid in top trays and cables of subsequent voltage grades in lower tiers of trays.

The HV power cables shall be laid in trays/on racks as follows:

i) In single layer only without exception.

ii) core cables to be laid in touching formation.

iii) Single core cables to be laid in trefoil groups.

iv) 1100V grade power cables shall normally be laid in single layer in trays / on racks.

v) Control and instrumentation cables can be laid up to a maximum of two layers in each tray/rack, if routing is difficult, otherwise one layer.

vi) Single core power cables for 3 phase AC circuits laid in trays/racks/ trenches in trefoil formation shall be held by trefoil clamps placed at an interval of 3m. The trefoil groups of cables shall be additionally tied by means of 3mm dia. nylon cord as follows:

vii) At an interval of 1m when laid in cable trays/racks.

viii) At an interval of 750mm when laid in trenches without cable trays.

ix) Control cables and small power cables on racks shall be run in ladder type cable trays supported on rack carrier arms. The cables shall be tied to tray rung by means of 3mm dia. nylon cord at an interval of 5000mm and also at bends.

18.20 Bending Radii for Cables

The bending radii for various types of cables shall not be less than those values recommended by the cable manufacturer.

18.21 Terminations, Clamping and Miscellaneous Details

Cable entry to motors, push button stations and other electrical devices shall be from the bottom as far as possible or from the sides. Top entry shall be avoided particularly for outdoor equipment.

Identification tags made from aluminium sheet shall be attached to each end of each cable by means of GI binding wire. Tags shall be additionally put at an interval of 30metres on long runs of cables and in pull boxes.

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All cable terminations shall be done with solderless crimping type lug. Cable terminations shall be done with double compression type brass cable glands.

Saddle type clamps to suit number of cables to be clamped at a particular location shall be used for clamping cables running along walls, ceilings, structures, etc. at 750mm interval.

Required number of glands & lugs shall be supplied. Glands shall be double compression type and of brass.

i) MV, HV and EHV Cable Terminations:

11kV, 33kV, 132kV and 400kV cable termination and jointing kits shall be of heat shrinkable / cold shrinkable.

ii) LV Cable Terminations:

All 1100V termination for XLPE/PVC power cables and control cables shall be by crimping type tinned copper / aluminum lugs. Cable termination will be done with suitable double compression type brass cable glands.

iii) Cable Joints:

Cable joints shall be avoided to the extent possible. If joints are unavoidable due to circuit length, more than permissible maximum drum length, they shall be heat shrinkable type having a short circuit withstands capacity of 40 kA for 1 sec. for MV cables and 50kA for 1 sec. for 1100V grade cables.

18.22 Fire Proof Sealing System (FPS)

18.22.1 Fire proof sealing system shall consist of:

i) Fire-stops/fire-seals for sealing of cable/cable tray and conduit/pipe penetrations, both horizontal and vertical through brick or RCC walls/floor, to prevent the spreads fire from one area which is separated from others by the resistant barriers.

ii) 'Fire-breaks' provided on long runs of cable racks/trays prevent the propagation of fire along the cable rack with a single fire-area or fire-zone.

iii) The FPS system shall also include all the necessary accessories and equipment required for supporting, holding in position and installation of the fire-stop/fire-break.

iv) The FPS system shall comply in all respects with the requirement of the codes and standards listed below.

a) IEEE-634

b) ASTM-E-814

c) ANSI-IEE-383

d) IEC-331

e) IEC-332

v) HV & LV cables shall be provided fire resistant paint as per applicable IS / NBC code. Fire paint shall be UL/ FM/ accredited lab approved with 2 hour rating.

18.22.1.1 Fire stop / seal

The FPS system adopted for cables or cable trays penetrating through walls and floor openings (if any), or cables passing through embedded conduits/pipes/pipe-sleeves, constitutes a 'fire stop/seal', which is meant to prevent spreading of fire between areas separated by fire-resistant barriers.

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18.22.1.2 Fire Break

The fire proofing system, other than fire-stops, adopted to retard flame propagation along long runs of horizontal or vertical cable trays in the same fire zone or area, in an event of a fire, shall constitute a 'fire-break' and shall be provided by applying a suitable fire-resistant coating on cables and cable trays for the required length, with or without a fire resistant panel, at the point of the fire break to obtain the fire-rating specified.

i) Performance Requirements

a) Requirement of fire stops

The material, design and construction of the fire stops shall be such as to provide the fire-rating of 120 minutes for a fire on any side and meet all requirements listed in this specification and the relevant codes and standards.

The material used in the fire stops shall be non-hygroscopic, compatible with the type of cables.

The fire stops shall be suitable for retrofitting of cables through the penetration seal without disturbing the sealing of the cables already existing.

b) Requirements of fire breaks

Each fire break shall have a fire-rating of 120 minutes and shall be capable of withstanding for the duration specified a fire on any side of the fire break.

Application of fire proof sealing system

18.22.1.3 Fire stops

i) Fire stops shall be provided for cable penetration openings listed below:

a) The passage of cables/cable trays / pipe sleeves/ embedded conduits through walls/floors.

b) Vertical raceways which carry cables between successive floors, if any, through openings provided in the RCC floor slab, shall be sealed by fire stops at each floor level.

c) Cable entry through openings in floor slabs below HT/LT switchgear, MCCs, various control and relay panels and other bottom entry panels, shall be effectively sealed by fire stops.

ii) Location of fire breaks

a) Fire breaks shall be provided on both cable rack and trenches at all cable tray intersections and tee-off.

b) On linear runs of cable trays between fire stops or fire breaks, fire breaks shall be provided at interval of 15metres on horizontal cable runs and 5m vertical cable runs.

c) Bidder shall estimate the requirement of fire sealing system based on the equipment layout,cable layout drawing prepared by him.

- **Tests on Fire Breaks**
- **Fire breaks shall undergo the following tests as per ANSI-IEEE-383:**
- **Ampacity test**
- **Flame test**

18.23 Testing and Commissioning of Cables

i) Cables shall be checked for insulation resistance before and after jointing.

ii) High voltage testing

iii) All HV cables shall be subjected to DC or AC (preferably DC) high voltage test after terminating but before commissioning as per Table 4 in IS: 1255.

iv) Routine test and acceptance tests shall be conducted on cables offered.

v) Type test certificates shall be furnished.

18.24 Electrical Equipment Installation

All the equipment supplied under this contract shall be neatly installed / erected as per normal industrial practices. All the safety equipment like rubber mats in the switchgear rooms, danger boards, first aid box, name plate etc & any other as required for the system and to meet the statutory requirements shall be included in the scope.

18.25 Earthing

Metallic sheaths, screens and armour of all multicore cables shall be earthed at both equipment and switchgear end.

Sheath and armour of single core power cables shall be earthed at switchgear end only. If specifically indicated in project specification/drawings, for long lengths of cables, multiple earthing may have to be adopted to safeguard against the presence of standing voltages under normal as well as under fault conditions.

Earthing of CT and PT neutral lead shall be done at one end only, as indicated in respective control wiring drawings.

18.26 Mandatory Spares

Sl No	Item	Unit	Quantity
1	**Cable And Cable Accessories**		
1.1	Control cables	% of total Qty for each type of cable	5
1.2	Signal cables	% of total Qty for each type of cable	5
1.3	EHV & HV Cable Termination kit of each type (if applicable)	sets of each Type	2
1.4	EHV & HV Cable Jointing kit of each type (if applicable)	nos. of each type	1
1.5	Lugs of each size	nos. of each type used	100

CHAPTER 19: ELECTRIC OVERHEAD TRAVELLING (EOT) CRANES

19.1 Scope of Work

Scope of work under this Chapter covers the provision of labour, tools, plants, materials and performance of work necessary for the design, manufacture, quality assurance, quality control, shop assembly, shop testing, delivery at site, site storage and preservation, insurance, installation, commissioning, performance testing, acceptance testing, training of Employer's personnel, operation and maintenance till the commissioning of all the Units, handing over to KHPL and guarantee for three years of EOT cranes for power house, Butterfly valve house and GIS cavern as per the specifications hereunder, each complete with all auxiliaries, accessories, spare parts and warranting a trouble free safe operation of the installation. The Systems shall be suitable for Ambient, Seismic, Altitude and other site conditions are detailed in General Technical Specifications.

The scope of work shall be a comprehensive functional system covering all supply and services including but not be limited to following:

19.1.1 200/40/10T EOT Cranes for Powerhouse

i) Two (2) nos. 200/40/10 metric tonnes powerhouse electric overhead travelling bridge cranes of approximately 19.5 m span, each crane complete with electric control panels, operator's cabin, remote radio controls, main and auxiliary hoists on a common trolley, brakes, safety devices, platform, ladders, fittings and connections and all necessary accessories.

ii) One (1) equalizer beam, fittings, connections, electric controls and other accessories required when the cranes are operating in tandem for lifting rotor.

iii) One (1) set of fabricated steel equalizer beam stand(s) for support when beam is not in use.

19.1.2 60/ 15T EOT Crane for Butterfly Valve House Cavern

i) One (1) no. 60/15 metric tonnes electric overhead travelling bridge crane of span approximately 9.0m, complete with electric control panels, cabin and remote radio control, main and auxiliary hoists on a common trolley, brakes, safety devices, platform, ladders, fittings and connections and all necessary accessories.

19.1.3 10T EOT crane for GIS Handling

i) One (1) no. 10 metric tonnes electric overhead travelling bridge crane of span approximately 15.2 m, complete with electric control panels both pendant and remote radio control, hoist on trolley, brakes, safety devices, platform, ladders, fittings and connections and all necessary accessories.

19.1.4 Miscellaneous Items

i) One (1) set of main runway rails with base plates, anchor bolts, rail clips, lock nut, end stops, limit switches, striker's plates, buffers etc. for each of the cranes.

ii) Two (2) sets of bridge rails with rail clips, lock nut, end stops, limit switches, striker's plates, buffers etc. mounted on each of the crane girders.

iii) One (1) set each of long travel feed rail power supply system complete with metal enclosures, conductors, collector trolleys, all fittings and connections etc. for total runaway length of the respective cranes as per layout drawings.

iv) Load testing of cranes at site including load arrangement and all logistics.

v) Lubricating oil, grease and hydraulic brake fluid for first filling of all components with 100% reserve, in non-returnable drums, for all the cranes.

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vi) All power cables, control cables and special cables, cable racks, cable glands, lugs, terminals, connectors etc. for cabling between equipment and devices covered in this chapter,

vii) Spare parts in accordance to clause 7.12 “Spare Parts” of this section.

viii) Tools and instruments in accordance to clause 7.14 “Tools and Instruments” of this section.

Bidder shall consider EOT crane/Electric hoist/ Manual hoist of suitable capacity as per design requirement meeting following criteria.

i) Equipment's which is more than 0.5T in weight is and to be handled for maintenance, Bidder shall provide suitable handling arrangement.

ii) For the equipment to be handled between 1T and less than 5T, electric hoist to be provided.

iii) If the equipment to be handled is more than 5T, EOT crane shall be considered with prior approval from owner.

Handling arrangement for all the auxiliary systems along with removal space for maintenance shall be provided by the Bidder.

Crane / Hoist capacity shall be selected considering 10% margin over the heaviest weight to be handled by crane / hoist, including equalizing beam and lifting beam.

Any other item(s) not mentioned specifically but necessary for the satisfactory completion of scope of work defined above, as per accepted standard(s)/best international practices.

19.2 Specific Design and Layout Conditions

19.2.1 200/40/10 T Power House EOT Crane

The powerhouse EOT and monorail cranes shall be required for handling turbine components, generator, transformer, associated apparatus and other equipment in the powerhouse. The cranes shall be used for the installation of above equipment as well as for the routine maintenance after completion of the powerhouse. The two powerhouse EOT cranes shall be capable of operation in tandem.

In coupled tandem operation, the powerhouse cranes shall be used to lift a complete generator rotor mass including lifting device. The cranes should be designed in such a way that the cabins are located besides each other during tandem operation and controlled by any one of the cabins. The Contractor shall supply necessary control and cables for this purpose.

The cranes shall also be used for handling main transformers from service bay and also for handling runner during repair and maintenance.

One monorail crane shall be installed under the bridge of powerhouse EOT crane. Monorail crane shall be arranged on a single under-running beam suspended beneath the bridge girder.

The power house EOT crane approaches are marked on drawing no. KHPP-ME-6017-GA-60001. However, the crane design shall be coordinated with the turbine, generator and transformer manufacturers for capacity and other provisions in the cranes with respect to installation layouts. The Contractor shall supply the required capacity of cranes if requirement is higher than 200T for main hook. The main hook as well as auxiliary hooks of EOT cranes shall have anti-sway arrangement.

19.2.2 60/15T EOT Crane for Butterfly Valve House Cavern

The 60/15 T EOT crane shall be used for handling of butterfly valve in the butterfly valve house cavern. The contractor shall supply the required capacity of crane if requirement is higher than 60T for main hook. The hooks of the EOT crane shall have anti-sway arrangement.

The crane design shall be coordinated with the butterfly valve manufacturer for capacity and other provisions in the crane with respect to installation layouts.

The butterfly valve cavern EOT crane runway length and lift are anticipated to be 60 m and 11 m respectively. The runway length and lift of hook may vary as per the site condition which shall be finalized during detailed engineering and no extra cost for the same shall be paid, at any stage.

19.2.3 10T GIS Cavern EOT Crane

The 10 T EOT crane shall be required for handling of GIS and associated equipment located in the GIS cavern. The crane shall be used for installation of the above equipment as well as routine maintenance after completion of powerhouse.

GIS EOT crane manufacturer may go through specifically the head room clearance shown in the layout drawings for installation feasibility, otherwise the under slung crane may be considered. However, acceptance in this regard shall be obtained from the purchaser.

The crane design shall be coordinated with the GIS design for capacity and other provisions in the crane with respect to installation layouts.

19.3 Standards

The cranes and their components shall be manufactured and tested in accordance with applicable Indian standards or equivalent international standard. List of some of the relevant major standards is given below. Latest version of these standards shall be applicable.

Sl. No.	Standard	Description
1	IS - 3177/BS: 466	Code of Practice for Electric overhead travelling cranes and gantry cranes other than steel work crane
2	IS - 807/BS: 2573	Code of practice for design, manufacture, erection and testing (Structural portion) of cranes and hoists
3	IS-5749/BS: 3017	Forged Ramshorn hooks
4	IS-2266/BS: 302	Specifications for steel wire ropes for general engineering purposes
5	IS - 6938	Code of Practice for design of rope drum and chain hoists for hydraulic gates
6	IS - 325/BS: 2960	Three phase induction motors
7	IS-13947	Contactors and motor starters electromechanical contactors & motor starter
8	IS - 2062	Steel for general structural purposes
9	IS – 3815	Point hooks with shanks for general engineering purpose
10	IS-1030	Carbon steel castings for general engineering purposes
11	IS-1875	Carbon steel billets, bloom, slabs and bars for forgings
12	IS - 210	Grey Iron castings
13	IS - 1363 (Part 1, 2, 3)	Hexagon head bolts, screws & nuts of product grade- C
14	IS-1364(Part1, 2, 3, 4, 5)	Hexagon head bolts, screws & nuts of product grade A & B
15	IS - 4460 (Part 1, 2, 3)	Gears - spur & helical gears - calculation of load capacity
16	IS - 800	Code of practice for general construction in steel
17	IS – 276	Wire rope slings and sling legs

19.4 Rating and Functional Characteristics

19.4.1 200/40/10 T Power House EOT Crane

Sl. No.	Item	Description
1	Number of Cranes	Two (2)
2	Duty or class of Crane	Class M5 using VVVF Control
3	Rated Capacity:	
3.1	Main Hoist	200 metric tonnes
3.2	Auxiliary Hoist	40 metric tonnes
3.3	Monorail Hoist	10 metric tonnes

Sl. No.	Item	Description
3.4	Crane Span	19.5 m (approximately)
3.5	Runway length	120 m (approximately)
4	Total Lift (with Load):	
4.1	Main Hook	31m
4.2	Auxiliary Hook	31m
4.3	Monorail Hook	35 m
4.4	Tentative clearances/ hook approaches are as per below:	
4.5	Minimum working clearance required for crane movement/maintenance from the centerline of rail and nearest side obstruction on upstream and downstream of powerhouse	500 mm
4.6	Maximum distance between bottom of gantry rail and the highest point of Crane	4400 mm
5	Terminal Position of Cranes no.1 (Service Bay end):	
5.1	Main/auxiliary/ monorail from the centre of the gantry rail on upstream side	1750 mm/ 2750 mm/2100 mm
5.2	Main/Auxiliary/ Monorail from the centre of gantry rail on downstream side	2000 mm/ 1000 mm/2350 mm
5.3	The distance of main and auxiliary hooks from inner edge of wall/nearest obstruction in their terminal positions at both the ends	4000 mm
6	Maximum operating speed (loaded):	
6.1	Long (bridge) Travel	25 m/min.
6.2	Cross (trolley) Travel	15 m/min.
6.3	Main Hoist lift	1.2 m/min.
6.4	Auxiliary Hoist lift	8 m/min.
6.5	Monorail hoist lift	8 m/min
6.6	Travel of Bridge	Maximum possible
6.7	Travel of Trolley	Maximum possible
7	Minimum Incremental movement (not greater than the given values):	
7.1	Main Hoist	1.5 mm
7.2	Auxiliary Hoist	1.5 mm
7.3	Bridge Travel	3.0 mm
7.4	Trolley Travel	3.0 mm
7.5	Monorail hoist	5.0 mm
8	Acceleration/deceleration for	
8.1	Bridge Travel	0.10 m/sec2
8.2	Trolley Travel	0.08 m/sec2

19.4.2 60/15 T Butterfly Valve House Cavern EOT Crane

Sl. No.	Item	Description
1	Number of Cranes	One (1)
2	Duty or class of Crane	Class M5 using VVVF Control
3	Rated Capacity:	
3.1	Main Hoist	60 metric tonnes
3.2	Auxiliary Hoist	15 metric tonnes
4	Crane Span	9.0 m (approximately)
5	Runway length	60 m (approximately)
6	Total Lift (with Load) :	11 m (approximately)
7	Tentative clearances/ hook approaches are as per below:	

Sl. No.	Item	Description
7.1	Minimum working clearance required for crane movement/ maintenance from the centerline of rail and nearest side obstruction	400mm
7.2	Maximum distance between bottom of gantry rail and the highest point of Crane	2400 mm
8	Terminal Position of Crane	
8.1	from the centre of the gantry rail on U/S side	1300 mm
8.2	from the centre of gantry rail on D/S side	1700 mm
8.3	The distance of main and auxiliary hooks from inner edge of wall/nearest obstruction in their terminal positions at both the ends	3500 mm

19.4.3 10 T GIS Cavern EOT Crane

Sl. No.	Item	Description
1	Number of Cranes	One (1)
2	Duty or class of Crane	Class M5 using VVVF control
3	Rated Capacity	10 metric tonnes
4	Crane Span	15.2 m (approximately)
5	Runway length	109 m (approximately)
6	Total Lift (with Load)	19 m (approximately)

19.4.4 Common for Butterfly Valve House Cavern (60/15 T) and GIS (10T) EOT Crane

Sl. No.	Item	Description
1	Maximum operating speed (loaded) :	
1.1	Long (bridge) Travel	15 m/min.
1.2	Cross (trolley) Travel	10 m/min.
1.3	Main Hoist lift	1.2 m/min.
1.4	Auxiliary Hoist lift	5 m/min.
1.5	Travel of Bridge	Maximum possible
1.6	Travel of Trolley	Maximum possible
2	Minimum Incremental movement (not greater than the given values) :	
2.1	Main Hoist	1.5 mm
2.2	Auxiliary Hoist	1.5 mm
2.3	Bridge Travel	3.0 mm
2.4	Trolley Travel	3.0 mm
3	Acceleration/ deceleration for	
3.1	Bridge Travel	0.10 m/sec2
3.2	Trolley Travel	0.08 m/sec2

The dimensions are tentative and shall be finalized at the detailed engineering stage for achieving better dimensions only. The Contractor shall, however, co-ordinate the lifting requirement of machine components for erection with respect to the layout and dimension of powerhouse.

19.5 Performance Criteria and Guarantees

The electric overhead travelling (EOT) cranes along with all auxiliaries and accessories shall be capable of performing intended duties under specified conditions. The Contractor shall guarantee the reliability and performance of the individual equipment as well as of the complete system.

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The cranes shall be capable of raising, lowering holding and transporting their rated loads without any damage to or excessive deflection of any component.

The following shall be maintained in the operation of the cranes, with all brakes adjusted and functioning correctly and hook carrying rated load. Minimum possible travel/incremental movement are given below:

i)	Main Hoist vertical movement	: 1.5 mm
ii)	Auxiliary Hoist vertical movement	: 1.5mm
iii)	Bridge travel	: 3.0 mm
iv)	Trolley travel	: 3.0 mm
v)	Monorail travel	: 5.0 mm

The vertical deflection of crane girders caused by the rated load plus all dead load should not exceed 1/1000 of the crane span.

19.5.1 Safety Requirements

In the design of Crane, all safety regulations as applicable with Factory Acts, Indian Electricity rules etc. as prevailing in the country and the site of installation shall be taken into consideration and provided for.

In the event of extreme variation in supply voltage outside the expected limits defined in clause 1.2 of General Technical Specifications, there shall be total load control and measures shall be taken to place the handled equipment in a secure position.

Correct vertical motion functioning shall be guaranteed within the abovementioned ranges of expected frequency and supply voltage variation.

In the event of a loss of electrical supply, load control shall be ensured.

Collisions of trolleys and pieces of equipment with buffers shall not endanger load control.

19.6 Design and Construction

19.6.1 General

The EOT Cranes shall be electrically driven, single trolley, double girder, and overhead travelling type. The 10T GIS EOT crane shall be single girder EOT crane. The cranes shall operate on runway rails. The bridge of the crane shall be carried on sufficient number of wheels, mounted on trucks, designed to distribute the load equally on the truck beams and wheels and to allow the wheels to adjust themselves to the irregularities of the rail. Suitable platforms shall be provided for access to bridge trucks. Suitable walkways of sufficient width shall be attached to the outside of each bridge girder. Power shall be supplied from the feed rail power supply system mounted on convenient height along the length of powerhouse.

The dimensions of run length and crane span are tentative and shall be finalized at detailed engineering stage only. The Contractor shall supply the materials/equipment as per approved drawings and bill of materials and no extra cost shall be paid for any variation on this account.

The control system shall contain all the necessary controls for the operation of all the movements of bridge, trolley, main hoist, auxiliary hoist and monorail. For handling the rotor, both of the powerhouse EOT cranes shall be controlled by one cabin. The Contractor shall supply necessary control and cables for this purpose.

Along with operator cabins, powerhouse and butterfly valve house EOT crane shall be provided with necessary radio controls to perform all operations of the crane. These radio controls shall be in addition to the control provided from operator cabins of the EOT crane with suitable interlocks so that only one control is available for use at any time to perform the crane operations. GIS cavern EOT cranes shall be provided with detachable type pendant controller and remote radio control.

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19.6.2 Allowable Stresses

The structure parts of the crane shall be designed for the following load combinations and unit stresses:

i) Dead load, live load, impact load and horizontal forces with resulting unit stresses not exceeding 70% of the calculated allowable unit stresses as per standard,

ii) Dead load, live load and collision forces resulting unit stresses.

19.6.3 Bridges

The Crane Bridge shall be of box type all welded construction with web plates stiffened by suitable diaphragms. All parts of the crane and runway rails shall be designed to sustain the loads and the combination of loads listed. The bridge girder shall be designed in accordance to the IS: 3177 and IS: 807.

i) Dead load.

ii) Live loads.

iii) Vertical impact load.

iv) Braking load.

v) Temperature effect.

Each crane shall consist of two bridge girders supported on end trucks. The girder end connections to trucks shall be rigid so as to prevent skew in operation of crane. The girders shall be designed to safely carry the full rated load without undue vertical or, lateral deflection or vibrations.

Bridge shall carry the rails on which a wheeled trolley is to run. The girder shall be designed so that vertical deflection caused by the safe working load and weight of crab in the central position (without taking into consideration the impact factor) shall not exceed 1/1000 of the span. The unit stress, slenderness ratio as well as factor of safety assigned on designing various members shall be given in Technical Data Sheets. The design of the bridge girder shall take into account the transport limitations as mentioned in General Technical Specification. If a split joint is required it shall be of bolted type.

19.6.4 Bridge Travel Mechanism

The bridge travel mechanism shall comprise of electric motors for driving at least 25% of the bridge wheels on each rail. The motors shall be located near each end of the bridge and connected to separate gear reduction units. Longitudinal travel of the Crane shall be affected in such a manner that equal speed is ensured at each end trucks without skewing.

The motor shall drive the bridge wheel through a totally enclosed gearbox. Gears shall be herringbone/helical type. The motion shall be free from vibration, rocking etc. under all conditions of operations and the crane structure shall not have tendency to get out of line. All gear reducers and drive mechanisms shall be designed and located to enable easy bridge wheel replacement within the confines of the powerhouse or other space limitations.

Foot switch shall be provided which shall be, operated from the cabin of crane to release/apply the brakes. Wheel stopper shall also be provided along with buffer stopper for long as well as cross travels, so that in case of buffer stopper failure, the wheel stopper shall prevent the trolley from derailing.

19.6.5 Trolley

The trolley shall consist of a welded form of structural steel section adequately braced to withstand vertical, lateral and torsional strains without undue deflection, and properly machined to receive the hoisting drums, wheel axles and motors for hoisting and cross travel. The trolley wheels and winding drums shall have heavy-duty roller bearings. Trolley wheels shall be made of rolled steel or forged steel. Each wheel shall be fitted with two roller bearings

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each mounted in a capsule housing held in place with two through bolts. Trolley wheels shall be double flanged. Bearing caps shall be provided with fittings for pressure lubrication. Bearing housing shall be so designed as to permit easy removal of shaft. On the bottom of the trolley frame on each side, double end spring buffers shall be provided to engage stops at each end of the bridge. The hoisting arrangement shall be so installed on the trolley, so that the rope reeving arrangement resulting there from shall ensure lifting of load in almost vertical line with minimum swing or side movements.

19.6.6 Trolley Drive Mechanism

The trolley drive motors should be mounted on the trolley frame and arranged to drive at least one driving wheel on each side of the trolley frame through gearing and shafting.

The trolley travel mechanism shall comprise of at least two (2) nos. electric motors and totally enclosed speed reduction gear unit, one for each end of the trolley to drive two trolley wheels, designed to ensure equal speed. The drive mechanism shall ensure steady motion, free from vibration and rocking. Two automatic electro mechanical brakes capable of bringing the motion of fully loaded trolley safely to rest, in the shortest possible time, with least possible shock shall be provided.

19.6.7 End Trucks, Wheel and Axles

The Crane Bridge shall be carried on the end trucks fitted with drive and idle wheels. Trucks shall be fabricated from high-grade structural steel. Heavy gusset plates shall be attached to the bottom of the truck to insure rigidity and squareness. Each truck shall be fitted with double flanged rail wheels with roller bearings mounted on rotating axles, buffers etc. for easy maintenance. The truck shall be arranged so that wear may be compensated in order to maintain the drive gear in proper condition. The size of journals shall be ample to carry the rated capacity load at specific speed without excessive heating during continuous operation. All trucks shall be designed to permit easy wheel removal.

Trucks shall be equipped with rail sweeps, extending below the top of rail and projecting in front of the truck wheels, to push forward off the track, any object placed across the rail.

Safety lugs shall be provided which shall extend below the top of rail on both sides to prevent the trucks from leaving rails. Wheel assembly shall be arranged such that, replacement of a wheel can be achieved from the side without undue difficulties.

The end trucks shall be designed to contact end stops and the contact faces shall be fitted with resilient bumpers or, spring buffers. The end stops shall be provided and they shall be designed such that they contact the face of the buffer fitted on end truck and not the wheel. The stops shall be attached at each end of runway rails.

The design and construction of track wheels shall be in accordance with IS: 3177-1999. The bridge shall be carried minimum 8 (eight) numbers of wheels on each side for crane capacity 200MT and above. All wheels shall be double flanged, machined or ground to size. The wheels shall be made of forged steel or rolled steel and shall be mounted in such a manner so as to facilitate removal and replacements. The steel shall not contain more than 0.06 percent of either Sulphur or phosphorus. The hardness of the wheel rim should be maintained between 300 to 350 BHN with minimum depth of 10mm.

The tread width shall have proper clearance for the railhead and shall be of sufficient size to withstand maximum static and rolling loads as per relevant Indian Standards. The tread diameter shall be as per relevant Indian Standards and preferably be standardized to size specified in relevant standards. The truck axles shall be made of forged carbon, or alloy steel and shall be accurately turned ground and polished at the wheels. All axles shall be forced fit into the wheel and the driving wheels shall be keyed to the axles in addition to the forced fit.

Truck wheels shall be provided with roller bearings with high-pressure grease lubrication. All bridge truck bearings shall be interchangeable. Wheels bearings and journals shall be easily removable from the truck bodies.

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19.6.8 Hoisting Machinery

The main hoist and an auxiliary hoist (as applicable) shall be mounted on trolley framework. The hoists shall be driven by suitable motors, gears to obtain the required hoisting speed and VVVF drives. Each hoist shall be provided with two brakes working on different principles. Equalizers shall be included to assure that the tension in the rope is equalized.

19.6.8.1 Hoist Drum and Wire Rope

The trolley shall be provided with separate rope winding hoisting drum for main and auxiliary hoists. Each drum shall be designed to take full length of hoisting rope in one layer without layer winding. The end of the wire rope shall be anchored to the drum in such a way that the anchorage is readily accessible. Hoisting drum shall be flanged or guarded and provided with deep-machined grooves in sufficient nos. to leave at least two coils of rope in the groove when the hook is in the lowest position. At least, one groove shall remain unused when the hook is at highest position. Drum shall be designed to withstand compressive stress caused by the wound on rope, the bending stress due to beam action on the drum and torsional stress. The factor of safety of the rope drum shall not be less than five (5).

The wire ropes shall be of proper design and construction for crane service. The wire ropes shall be of extra flexible plow steel or alloy steel conforming to latest relevant Indian Standard. Factor of safety based on the nominal breaking strength and safe working load of the rope shall not be less than six (6).

19.6.8.2 Design of Hoist Drum

Hoist drums shall be of rolled steel, welded construction and shall be duly stress relieved. Lead angle, grooving, diameter and other parameters of hoist drum design shall conform to relevant Indian Standards (IS 3177: 1999).

19.6.8.3 Lifting Tackle and Hook

The lifting tackles shall consist of a lower block and hook, necessary sheaves, flexible steel wire rope etc. The lower block shall be a heavy steel housing to support the sheaves and hook. The load block shall be of enclosed design.

The hook and block shall be arranged to lift without twisting and sidewise pull of load. For powerhouse and Butterfly valve house EOT cranes, the main hook shall be “Ramshorn” type conforming to Indian standards and auxiliary hook shall be of Shank type point hook conforming to Indian standards. Hooks shall be swiveled on antifriction thrust bearings and have adequate capacity to handle maximum load. The thrust bearings shall be provided with facilities for lubrication.

The hooks shall be free to rotate 360° when supporting rated load. Hooks shall be fitted with safety latches designed to preclude inadvertent displacement of slings from the hook saddle.

Hooks and lifting eyes shall be made of forged annealed alloy or carbon steel. Hooks shall be designed such that the resultant load on the hook passes through the centerline of the shank. Prior to machining, all hooks shall be subjected to ultrasonic test and wet magnetic particle inspection of all surfaces of the forging.

19.6.9 Runway Rails

The runway rails along with sole plates, fixing clamps etc. for bridge travel, shall be designed and supplied by the Contractor as per relevant Indian Standards. The rails for powerhouse EOT crane shall be at least CR-100 and shall extend to the full length of the powerhouse including the service bay in power house. The EOT crane rails shall be provided with continuous sole plate of at least 12mm thick. The trolley rails shall be of the same size, quality, material and class as that of main runways rails. The rails shall also be supported side way to withstand the starting and stopping of trolley with load. The Contractor shall supply all the materials required for fixing the bridge and trolley rails.

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19.6.10 Operator's Cabin

The two powerhouse and butterfly valve house cavern EOT cranes shall be equipped with operator cabins complete in all respects in accordance with relevant standards. The operator's cabin shall be of structural steel frame to give an aesthetic look and shall be provided with protective cage, suitable for indoor service. The cabin shall be suspended from the outside girders of the crane and braced to the crane so as not to sway, swing or shake.

The cabins of powerhouse crane shall be placed towards the upstream side of the powerhouse so as to give the operator the maximum and best view for all operations and as clear view as possible of the surroundings.

Cabins shall have ample space for containing the control equipment and for performing all crane operations and maintenance as per provisions of IS 3177:1999. A good comfortable seat with back, an electric fan and suitable no. of background LED lights shall be provided. The control of the monorail cranes shall be from both the crane cabin and remote radio station.

A ladder shall be provided for access from the cabin to the bridge walkway. Another ladder shall be provided on the back of the cabin to provide access from the catwalk to the walkway on the cabin side of the crane. Suitable doors with safety position detector and an emergency light shall also be provided. An emergency ladder foldable type shall be provided for access from service bay floor to operator's cabin for powerhouse EOT.

Adequate number of CO2 gas cylinders, each of 4.5kgs capacity, for fire extinguishers shall be provided in the cabin, on the bridge, suitably located and properly authorized.

19.6.11 Brakes

Automatic electro-mechanical DC brakes and electro hydraulic thruster's brake for each motor of LT travel shall be provided. In addition, foot switch shall be provided in the cabin for operation of the electro-mechanical DC brakes and electro hydraulic thrusters brakes for LT.

An automatic electro-mechanical DC brakes capable of bringing the motion of fully loaded trolley safely to rest shall be provided. In addition, a thruster brake shall also be provided for each motor of CT motion.

All brakes provided on each bridge and trolley drive motor shall have a capacity not less than 150% of the full load torque of the bridge or trolley drive motor. The monorail hoist's holding brakes shall be rated for not less than 150% of the full load torque of the hoist motor.

Two brakes working on different principles shall be provided for all hoists. Hoisting motion shall be fitted with an electro-mechanical DC brake and electro hydraulic thruster brakes. The hoisting brakes shall be fail safe and shall have adequate capacity to bring the fully loaded crane to rest in shortest possible time and to arrest the motion and sustain any load up to and including test load at any position while hoisting and lowering. Each brake shall be capable of meeting the complete hoisting requirements independently. However, monorail hoist arrangement shall have Electro- hydraulic thruster brake and cross travel motion of monorail hoist block shall have AC/DC electromagnetic type brake.

Springs for the electro-mechanical brakes shall be of the compression type and shall have adequate factor of safety. The brake pedals shall have a non-slip surface and it shall be possible to apply foot brake with a force not exceeding 25 kg force.

All brakes shall have ample thermal capacity for the frequency of operation required by the application and shall be adjustable to compensate for lining wear. The friction surfaces of all brake drums, wheels and discs shall be free of defects that interfere with operation.

All brakes on travelling motions shall be selected for 1-hour intermittent duty and shall be equally effective in both directions of movement. All holding brakes on hoist motions shall be designed for continuous duty. Magnets for all brakes shall be rated for continuous duty.

Braking system shall be automatically set when controls are released or power is interrupted.

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19.6.12 Gears

All cranes shall be provided with proper gearing, using least number of gears and pinions to accomplish the needed reduction. All gears in power- operated motions shall be machine cut conforming to relevant Indian Standard. The gear trains shall be in totally enclosed oil tight gear cases with welded seams. An inspection cover on the top of gear case shall be provided for quick and easy inspection of gears and for adding oil in the case. Adequate breathing and drainage facilities shall be provided on all gear cases. Means for clear and correct indication of the oil level in gear cases shall be provided. All gears not enclosed in gear case shall be properly guarded.

All gears shall be of cast steel/forged steel, shall be designed for the specified crane duty, and shall conform to relevant Indian Standards. The gears and pinion for all the motion shall be herringbone or helical type.

Gearbox casing shall be fabricated from tested quality cast steel or welded steel plates and duly stress relieved. The casing shall be effectively sealed against oil leakage. Gear cases shall be mounted on machined surfaces. Shims shall not be used.

19.6.13 Bearing

Bearings shall be of the ball or roller type and shall be designed to permit easy removal of the shaft. Bridge and trolley wheel bearings shall be of the roller type. All bearings shall be provided with proper lubrication or means of lubrication. Bearings shall be designed to exclude dirt, prevent leakage of oil or grease, and to eliminate the need for frequent lubrication. Shaft bearings shall be placed as close as possible to points of loading. Bearings shall be easily replaceable. Bearing housings shall be of cast iron, cast steel, or welded steel construction. The service life of all bearings shall be not less than 10,000 hrs. at the design speed and power. These service hours shall represent the life that 90% of the bearings shall complete or exceed.

19.6.14 Drip Pans and Covers

All bearing and gear cases shall be made oil tight. Suitable drip pans shall be provided to collect oil and grease, which may drip from bearings, gear cases and other components of the crane in case drip proof arrangement is not possible. Means for cleaning the drip pans shall be available. Dust cover shall be provided where necessary to protect sliding and rotating parts and to prevent dust from mixing with lubricant.

19.6.15 Guarding

All gears, wheels, pinions and chain drives shall be totally encased unless such parts are so situated in relation to the structure of crane as to be as safe as if complete encasement were provided. Effective guards shall be provided for revolving shafts and couplings unless every setscrew, bolt or key on any revolving shaft is sunk, shrouded or, otherwise effectively guarded. The sheaves of hook blocks fitted with two sheaves or less shall be guarded to prevent the trapping of a band between a sheave and the in-running rope. Guards shall be fastened securely.

19.6.16 Sheaves

Sheaves shall be manufactured from cast steel or forged steel or rolled steel. Sheave grooves shall be smooth and free from surface defects, which could cause rope damage.

The sheave pins shall be made of annealed carbon or alloy steel. All revolving sheaves shall be equipped with standard replaceable roller bearings with dust seals.

The diameter of the sheaves at the bottom of the groove, the lead angle and other parameter of sheave design shall conform to relevant Indian Standards (IS 3177:1999).

19.6.17 Couplings

All couplings shall be as per relevant standards and shall be designed to suit the maximum torque that may be developed. Alignment shall be such that solid couplings mate accurately. Flexible couplings shall be initially aligned with the same accuracy as solid couplings. Flexible couplings shall be fitted between motor shaft and gear drive when they are directly coupled.

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Hoist drums shall preferably be connected to gear box output shaft by means of flexible hoist drum couplings or by any other suitable method to cater for misalignment, frame distortion etc. and also to facilitate easy removal of hoist drum.

19.6.18 Electrical Apparatus and Control

19.6.18.1 General

A two way supply control switch shall be installed in the service bay which shall be fed A.C supply from two boards. A.C supply to runway conductors shall be fed from this switch. The Contractor shall supply all equipment and devices required for this.

Allowable temperature rise of the equipment shall be as prescribed in the relevant Indian Standards.

19.6.18.2 Motors

The crane shall be equipped with motors of ample capacity for performing the duties specified without exceeding the rated full load torque and shall conform to latest version of relevant Indian Standards.

All the motors should be totally enclosed type and shall be strong and sturdy to withstand shock and vibrations transmitted to them. The IP protection class shall be 55 and insulation class 'F' with temperature rise limited to class 'B'.

All motors shall be suitable for frequent start-stop, frequent reversing, frequent acceleration and mechanical braking. Motor shall be so located that terminals are accessible for inspection and maintenance and normal ventilation is not restricted.

All motors shall at least be of 60 minutes (40% CDF) rating with pull-out torque at least 2.5 times the rated load torque for permanent operation.

Electrical equipment mounted on bridge platform shall be enclosed type in sheet metal enclosure, with a provision for easy access to parts inside. The control panel shall be so spaced that efficient maintenance is possible and shall withstand the mechanical forces imposed by the crane under service condition.

19.6.18.3 Controllers

All hoist and travel motions of powerhouse and butterfly valve house cavern EOT cranes shall be cabin and remote control operated. All hoist and travel motions of GIS halls EOT crane shall be pendent and radio remote controlled.

The controllers shall be so located that they can easily be operated by one person and permit an unrestricted view of the load. The controllers shall be designed to permit easy inspection, adjustment and replacement of parts. All electrical equipment shall be suitably enclosed so that live parts shall not be exposed to accidental contact under normal operating conditions. All master control switches, manually operated switches, circuit breakers, starters, contactors, limit switches and relays shall be clearly and permanently identified by attached nameplates.

i) **Pendant controllers**

The GIS Hall EOT crane shall be independent travelling pendant controlled having its own electrification track and can move anywhere along the span of crane without being tied to the hoist. The pendant switches shall be capable of withstanding rough handling and harsh environmental conditions without being damaged and the cover shall be effectively secured.

Means shall be provided to prevent inadvertent operation from the floor while maintenance work is being carried out on the crane. Push buttons or switches shall be used in pendant control, which shall automatically return to the "Off" position immediately after they are released. One lockable type of push button shall be provided to switch off control power when the crane is not in use and if other means of switching

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off is not available. The weight of the pendant shall be supported independently of the electric cables by means of chain or wire rope.

ii) **Radio control**

Radio controls shall be provided for control of the powerhouse, GIS hall and Butterfly valve house cavern EOT cranes. Radio controls provided shall be in addition to the main controls with necessary interlocks so that the operator shall be able to use only one type of control at a time.

Main components of radio control shall consist of the following:

i) A portable transmitter,

ii) An antenna and receiver on the bridge,

iii) Amplifiers and other associated electronic circuitry,

iv) Each radio-controlled crane shall be equipped with a 100-W amber indicator lamp located beneath the centre of one of the bridge girders. This light shall be energized whenever the crane is in the radio control mode and the crane's master contactor has been energized.

Reliability, dependability and ease of maintenance shall be prime considerations in the design and construction of all components and parts of the equipment, to ensure positive operation of the system under all conditions of dust, moisture, temperature, vibration and electrical interference.

Radio control should be so designed that if the control signal for any crane motion becomes ineffective, that crane motion shall stop, and conversely signals received from any other source other than the transmitter shall not result in operation of any motion of the crane. The crane shall not take off on its own, respond to, or generate false commands. In case of power failure, the crane must stop.

Frequency ranges of 450-470 MHz shall be used for radio control communications:

The range of control shall be approx. 100 meters.

A key switch or equivalent security device on the transmitter, that can be used to prevent unauthorized use of the transmitter, shall be provided. Reduced maintenance requirements and long service shall be achieved through simplicity and use of conservatively rated, heavy-duty industrial type parts.

The design of the equipment circuitry and the application of components shall represent the state of the art. Wherever practicable, replaceable modules with reliable plug-in connections shall be used. The system shall be designed so that no field tuning adjustments is required when replacing a faulty module and shall permit a field change of the operating frequency by replacement of plug-in type components with minimum adjustment.

The radio control equipment shall be the type accepted by and shall conform to all applicable Bhutan/Indian standards, rules and regulations. The Contractor shall perform a frequency search and shall obtain necessary operating license on behalf of the Employer.

A carrying harness, belt shoulder strap or lanyard shall be provided on the transmitter.

Different motion switches shall be with different shaped knobs so that the motion can be selected by feel and the operator's vision.

19.6.18.4 Operation

i) The following functions of main powerhouse EOT cranes, Butterfly valve house and GIS hall EOT cranes shall be radio controlled (as per applicability):

a) Forward and reverse speed control of the bridge travel motion,

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b) Right and left speed control of each trolley (crane and monorail hoist) travel motion,

c) Up and down speed control of each hoist motion,

d) On and off control of the crane's master contactor,

e) On and off control of the lights on the underside of the crane bridge,

f) On and off control for the crane's alarm gong.

ii) The speed control of each motion shall provide for the direct radio control specified for that motion.

iii) Radio control shall be accomplished with a speed set point tele-metering system utilizing pulse rate, pulse width, or other similar systems. The speed of a motion shall be a direct function of the control lever's position and shall preferably utilize a logarithmic scale for greater control of the slower speeds. A "Jogging" system of controlling a motorized potentiometer or any other system in which the control lever's position corresponds to acceleration rather than a speed is unacceptable.

iv) Control information shall be transmitted using digitally coded information. The radio control system shall allow simultaneous transmission of all crane functions. A means of checking and detecting error in the digital data stream shall be provided to prevent a false operation of the crane. Radio interference signal shall not cause operation of any of the crane functions.

The power supply to the radio receiver shall be obtained from a branch circuit in the power distribution panel.

19.6.18.5 Speed Regulation

Speed regulation shall be accomplished utilizing WVF drive control system for all crane motions. The hoist and travel motions shall be provided with speed-regulations from 5 to 100% of rated speed. Minimum 6 (six) steps controller shall be provided for each hoist, CT and LT motion to accomplish any speed between 5 to 100% of rated speed. It shall be possible to set any speed at site without any problem within the above range. Speed control shall be achieved by adjusting the frequency of the motor electrical supply using thyristors. (Combination of power Rectifier Bridge and inverter).

The maximum acceleration produced by the control system shall be independent of the rate of change of the control lever position. The speed in the first lowering position shall not exceed 5% of the synchronous hoist speed when lowering any load up to rated load. The speed in the first hoisting position when lifting any load up to 125% of rated hoist capacity shall not exceed 5% of the synchronous hoist speed.

19.6.18.6 Control System Details

i) **For travelling movements:**

Each travel motion shall have a separate control lever or set of push buttons.

ii) **For Hoists:**

a) **General:** Separate controllers shall be provided for each hoist. Smooth acceleration shall be provided for all loads in both directions,

b) **Lowering:** The lowering speeds for all loads within the rated capacity shall be gradually increased by advancing the controller from the off position toward the full-on lowering position. The lowering speed shall not exceed 125% of the rated speed on any control position,

c) **Hoisting:** The hoisting speeds for all loads within the rated capacity shall be smoothly increased by advancing the controller from the off position toward the

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full-speed hoisting position. In no case shall any load up to 125% of rated capacity cause a hoist to lower when the controller is in any raising position.

19.6.18.7 Control Levers and Pushbuttons

All lever-operated controls shall have self-resetting controllers provided with a notch or latch, which in the "off" position prevents the handle from being inadvertently moved to the "on" position. Switch levers shall have automatic spring return to the "off" position. All pushbutton controls shall be of the momentary contact type, which make contact only while the button is depressed. Wherever possible, controls shall be arranged so that the movement of each controller handle shall be in the same relative direction as the resultant movements of the load. Pushbuttons shall be oriented in the same relative direction with respect to each other as the resultant movements of the load.

19.6.18.8 Limit Switches

Necessary limit switches shall be provided for all cranes including monorail hoists to prevent over winding, over traversing and over travelling. At least the following limit switches shall be provided for each crane:

i) Hoist driven limit switches for the upper and lower hook position,

ii) back-up over travel limit switch for the extreme upper and extreme lower position of each hoist,

iii) Lever-operated limit switches for both end positions of all travel motions.

Each limit switch shall be positive and unidirectional in action and its contact shall be so designed that it shall not freeze. Contacts shall be enclosed and protected from dust, moisture, and mechanical injury and shall be easily removable for replacement. The switches shall be of quick-break type, capable of stopping the equipment quickly under all conditions of speed and loading. The limit switches after being tripped shall automatically get reset. The actuation of the limit switch shall trip the main incoming circuit breaker or contactor and shall operate an audio- visual warning to the operator.

The manufacturer shall fit one or more devices to the bridge of the crane to give warning of the approach to the danger or another crane using infrared light sensors. Limit switches shall be so arranged that they can be readily tested.

19.6.18.9 Detection Devices

i) Over speed detection - Each handling device (AH, MH, CT and LT motion) shall be equipped with an over speed detection device, to check the maximum speed under any load. They shall be set at 115% of rated speed.

ii) Load control device – Load control device shall be provided for main and auxiliary hoist of powerhouse EOT cranes which shall display the hoisted load value.

iii) Unbalance Detection – Unbalance detection shall be provided during tandem operation. Balancing system shall be equipped with an unbalance detection device that shall stop the hoisting motion.

iv) Detection of brake wear – Brake wear detection shall be provided.

v) EHT brakes of all motions. This protection shall set off a sound alarm.

vi) Overload detection – Each hoisting (MH and AH) motion shall be equipped with an overload detection device that shall stop the hoisting motion. In case of overload and after local resetting, uptake shall remain prohibited but other motions shall be allowed. After removal of the cause of overload, normal operation shall resume.

19.6.18.10 Protective panels

The power supply from main collectors shall be protected by a three pole main line contactor and totally enclosed circuit breaker with a minimum interrupting capacity of 40 kA at 415 V

to switch off power supply to the crane with provision to lock in open position. Electrical interlocks shall be provided to prevent the main circuit breaker from being closed unless all the controllers are in 'OFF' position. The circuit breaker control circuit shall be so arranged that it shall not be possible to close main circuit breaker when the contactor of a particular motion has failed to open although the corresponding controller has been brought to its 'OFF' position. Indicating lamp for 'ON' and 'OFF' position of circuit breaker shall be provided.

The following protection shall be provided for all motors:

i) Single phase protection,

ii) Instantaneous over current protection,

iii) Thermal overload relays,

iv) Under voltage protection.

The contacts of protective relays shall be so worked that the operation of any relay shall trip the main contractor, thus making it necessary to bring all the controls to OFF position before restarting the motor. The instantaneous relays shall be adjustable between 200-300% of motor full load current.

All switches, contactors shall be enclosed in suitable cabinet placed in accessible location.

19.6.18.11 Long Travel Current Collection System

Each crane shall be provided with an approved feed rail power supply system. The feed rail system shall be of the shrouded metal enclosed, collector bus way type with internally supported conductors and collector trolley and shall have no live parts outside of the enclosure. Material of the conductor shall be copper.

The full current-carrying capacity of the system shall be maintained throughout. The feed rail system shall consist of an assembly of standardized, fully interchangeable units and shall include expansion sections at each building contractions joint, feed box, door track sections or other means of removing the collector trolley, coupling sets, dead-end caps track hangers and power take off collector trolleys as required for the complete system.

19.6.18.12 Power Conductors for the Crane Trolley and Monorail Hoist (cross travel current collection system)

Trolley power conductors shall be of the festooned insulated wire type. Each motor on the trolley shall have separate conductors for the power and in no case shall a power conductor be used as a common conductor for more than one circuit.

19.6.18.13 Cable Wiring and other Conductors

All wiring shall be laid on perforated cable trays or clipped on the crane structure by suitable device. All the cables shall have sufficient current carrying capacity as per relevant Standard specification. Conductor for power and control cables shall be armoured copper and FRLS type.

19.6.18.14 Lighting and Convenience Outlets

The permanent 230 volts lighting system for each crane shall consist of suitable nos. of 400W LED lighting units to illuminate uniformly the area under the crane and 2 nos. 40W LED in operator’s cabin. The ladders, platforms and walkways shall be equipped with vapour-tight incandescent industrial lighting fixtures with clamp or screw guards.

Convenience outlets at each end of the bridge and two in operator's cabin shall be provided. One all-purpose fan shall be fitted in operator's cabins.

19.6.18.15 Alarm Gong

An electrically operated loud alarm gong or buzzer, which shall sound while the crane is in motion, shall be furnished with each crane. The alarm gong shall also be operable from a conveniently located switch when the crane is not in motion.

19.6.18.16 Earthing

The crane structure, motor frames and metal cases of all electrical equipment including metal conduit or, cable guards shall be effectively connected to earth complying Indian Electricity rules 1956 and IS 3043.

19.6.18.17 Emergency Push Button

Emergency push button shall be provided in the cabin/pendant controller/remote control unit for emergency tripping. The push button shall be so arranged as to immediately put off the main supply and apply all the brakes simultaneously irrespective of controller position.

19.6.19 Other Construction Details

19.6.19.1 General

All fastening shall be adequate to hold the parts in place under all condition of service. All steel castings, steel forgings and wrought steel wheels and sheaves shall be annealed properly. Steel used in crane shall be of tested quality. The unit stresses values and slenderness ratio assumed in designing various members, shall be furnished by the Contractor.

19.6.19.2 Bolts, Nuts, Screws, Washers and Fasteners

Bolts and nuts for mechanical equipment shall be semi-finished and shall have hexagonal heads. All bolts and setscrews in rotating parts shall be locked. Bolts in tension shall be avoided wherever possible. Tapered washers and tapered pads shall be provided on the underside of steel sections with tapered flanges and shall be tack-welded in place.

19.6.19.3 Keyways

Connections subject to torsion such as couplings, driving wheels, and drive gears shall be keyed to the shafts with rectangular keys. The keys shall be sized to be within safe bearing and shearing limits of the materials in contact.

19.6.20 Miscellaneous Components

19.6.20.1 Walkways and Ladders

Ladders, platforms, walkways, hand hold, foot hold etc. necessary to give safe access to and movement in the cabin, bridge drive and trolley drive mechanism, and all other components of the crane needing inspection maintenance, lubrication and repair shall be provided for. Walkways shall be provided on both sides along the entire length of the bridge. All walkways and stair ways shall be of rigid construction, with hand railing and non-skid checker plate treads or grating, toe-boards not less than 0.1 m high. Walkways shall be continuous and permanently secured. Walkways shall have a clear passageway.

19.6.20.2 Bumpers

Bumpers shall be attached to the bridge trucks and the trolley. The bridge shall have four bumpers one at each corner arranged to meet the crane stops. The trolley shall have two bumpers on each side placed to meet the trolley stops. The bumpers shall be fastened to the trucks and the trolley and shall be capable of bringing the crane and the trolley to a gradual stop when travelling at rated speed in either direction.

19.6.20.3 Holding Clamps

As a safeguard against movement of crane off the rail during an earthquake, suitable provision to contain the movement of crane shall be made. Clamps to keep the crane in a locked condition while not in operation and indication of locking in cabin/pendant shall be supplied and arranged.

19.6.20.4 Cradles for Load Test

For load and overload tests suitable cradles, complete with hoisting attachments, slings etc. capable of accommodating test load shall be supplied. The design of cradle should be got

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approved by Employer indicating its iron weight. The cradle shall become property of Employer.

19.6.21 Auxiliary System and Devices

19.6.21.1 Lubrication System

Provision shall be made for lubricating all bearings, gears and other moving parts, which shall be easily accessible from working platform of the crane. The wheel bearings, shaft bearings, sheave and drum bearings shall be provided with fittings for grease lubrication. For bearings that are not accessible from a safe position, tubing or piping should extend the grease fittings from the bearings to accessible locations. Positive oil bath lubrication shall be provided for the hoist, bridge and trolley gear cases and their integral bearings. A lubricating chart shall be provided indicating all the lubricating points, the type of lubricant and recommended frequency of lubrication. Grease, lubricating oil and hydraulic brake fluid required for initial filling of all the equipment plus 100% reserve shall be furnished with each crane.

19.6.21.2 Anti-drip Provisions

Cranes shall be designed to preclude leakage of lubricants onto the lifted loads or the floor. Equipment and components which cannot be made leak-proof shall be fitted with suitable drip pans. Drip pans shall be manufactured of steel and designed to permit removal of collected lubricant.

19.6.21.3 Safety Devices

Following safety devices shall include but not limited to the following:

i) Rail sweeps at extremities of end carriage,

ii) Safety lugs under end carriage to prevent failing of crane beyond 25mm in the event of breakage of axles,

iii) Safety guards shall cover pulleys and exposed rotating parts like couplings and shafts,

iv) A guard between the two bridge girders to prevent contact between wire rope and conductors,

v) Hand railing on walkways and staircases,

vi) Toe-guard and hand railings along other edges of platform,

vii) Off-position interlock on the controllers so that a motion cannot be started unless the controller handle is first brought down to off- position,

viii) Emergency STOP push button in cabin/pendant/ remote control unit,

ix) Electrical interlock for reversing contactors,

x) Anti-collision devices to prevent collision of the two powerhouse EOT cranes,

xi) Overload relays, MCCBs and HRC fuses for protection of motors,

xii) Limit switches for all motions

xiii) MCCBs in the service bay to trip A.C power supply to crane in case of overloading/short circuit.

19.7 Tests

19.7.1 Shop Tests

i) **General:**

The Owner or his authorized representative shall have access to the manufacturer's work at all reasonable times for the purpose of witnessing the manufacture, inspection of assembly, match marking etc. and testing of all the components, subassemblies and assemblies of complete crane. The Owner's engineer may reject any work found

defective or unsatisfactory. The contractor shall furnish indicating the process of inspection for manufacture of component quality assurance plan. Customers hold points shall be clearly marked on the plan.

ii) **Shop Assembly and Match Marking:**

The crane shall be completely assembled, operated and load tested in the shop also and checked for adequacy of design and suitability for reliable, safe and proper operation. The parts of the crane shall be delivered assembled in as large units as practicable for field erection and handling.

Field connection shall be fitted in the shop and match marked suitably for each field erection.

All match marks shall be clearly visible and legible. Six copies of all match marks diagram shall be furnished with crane for field connection.

iii) **Tests at Manufacturer's Work:**

All the routine and acceptance test as specified in IS: 3177 shall be conducted in presence of Owner’s representative.

All material furnished shall be of tested quality and all work performed shall be subject to rigid inspection as specified in relevant International or Indian Standard and no articles or material or supplies shall be dispatched until the dispatch instructions are issued by the employer, which shall be issued only after all test's analysis and shop inspection have been completed or certified copies of reports or, results of tests and analysis have been accepted by Owner. Duplicate copies of manufacturer tests certificate shall be submitted to the engineer as soon as the tests are completed. In case test certificates are not available for any of materials, the same shall be tested if requested by the engineer and only those materials, which fulfil the requirements of the specifications, shall be used.

All the required tests as per standard/specifications shall be carried out at Contractor’s expenses. If any component of the equipment fails in the specified test, the same shall be replaced/rectified and again offered for inspection.

The Contractor shall submit the Type Test reports in respect of all the major components as per requirement of the latest standard for examination. The Employer may at his option, get any or all the type test or any other test of a reasonable nature carried out in presence of Owner's inspector for which payment shall be borne by the contractor.

The manufacturer shall state the plan of manufacture, testing and inspection of the various works in the contract, and the representative of engineer shall also be entitled to access to manufacturer's or, sub-contractor's work at any time during working hours for the purpose of inspecting the manufacture of equipment and materials.

Full load and 25% overload test shall be done at manufacturer’s work on hoisting and cross travels motions.

Tests to verify specified speeds under load conditions and tests about deflection bridge girders under safe working load at rest and with crab in a central position as per standard shall be done.

Operation of brakes as per relevant Indian and International Standards

iv) **Material Tests:**

The manufacturer shall perform all required material tests and deliver the required number of test certificates. The raw materials from which the test specimens shall be obtained shall be provided by the Contractor.

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For highly stressed or very important parts, at least two tensile tests and six notched bar impact tests shall be performed on opposite directions of the tested piece.

The following information shall be obtained from the tensile test:

a) Yield point,

b) Tensile strength,

c) Elongation,

d) Transverse contraction,

For the notched bar impact test, the impact value shall be obtained at +20°C ambient temperature.

The standards for acceptance are based on the following codes:

a) Minimum requirement for important cast pieces: ASTM code class 2 or equivalent,

b) Minimum requirement for important welding: International Institute of Welding Acceptance Code,

c) Minimum requirement for ultrasonic tested sheet-steel used for parts of major importance: class 2 or equivalent.

19.7.2 Field Test

After installation at site, the contractor shall repeat all the tests conducted earlier at his works in accordance with those specified above. In addition, all the tests as specified in IS 3177 shall be conducted.

The contractor shall furnish a complete outline of the proposed methods and procedures to be followed for the testing, including a list of equipment and instruments to be used, to the Owner's representative for review at least 60 days before the scheduled testing.

All necessary materials and labour for performing all the above tests shall be provided by the contractor.

The load for full load and 25 % overload test shall be arranged by Owner.

19.7.2.1 Deflection Test

Deflection test as per IS: 3177 shall be conducted with 25% overload both at works and site.

The deflection test shall be carried out with test load at rest and with the crab in central position.

The measurement shall not be taken on the first application of load. Datum line for measuring the deflection should be obtained by placing the crab on the extreme end of the crane span with smaller hook approach.

19.7.3 Test Reports

Shortly after completion of the field acceptance tests the Contractor shall prepare and forward draft copies of the field acceptance test report to the Employer for review. After review and acceptance, the contractor shall furnish six (6) copies of the final report.

19.8 Quality Control and Assurance

The Contractor shall submit detailed Quality Assurance Plan and Inspection Schedule for Employer's review and approval in accordance to clause 12 of General Technical Specification.



19.9 Drawings, Documents and Design Calculations

19.9.1 Design Memorandum

The Contractor shall submit to Employer a design memorandum prepared in accordance to clause 2.5 "Design Memorandum", of General Technical Specification.

19.9.2 Drawings and Documents

The Contractor shall submit all the drawings and documents in accordance with requirements stipulated in clause 2.6 "Drawings & Documents to be supplied by Bidder" of General Technical Specification.

19.9.3 Design Calculation

The Contractor shall submit the design calculation in accordance to clause 2.6.4 "Design Calculations" of General Technical Specifications of Volume-4 covering at least the following, for review/ acceptance:

i) Calculation for allowable stresses, factor of safety and other parameters for designing the EOT cranes,

ii) Calculations for selection of motor, brakes, DSL conductor, runaway rails and cross travel rails etc.

iii) Calculation for design of bridge girder, end carriage, lifting beam, cradle, girder joint,

iv) Calculation for design and selection of wire rope, rope drum sheaves and wheel size.

19.10 Delivery, Installation and Commissioning

The Contractor shall follow the general requirement of Delivery, Installation and commissioning as per relevant clauses in General Technical Specification.

19.11 Schedule of Requirements

19.11.1 For Power House Crane

19.11.1.1 Main Equipment and Accessories

Sl. No.	Description	Quantity
1	EOT cranes each 200T/40T capacity suitable to operate in tandem as and when required, each with a 10 T capacity monorail hoist provided underneath the girders, complete with all accessories, slings etc.	Two (2) Nos.
2	Runway rails complete with sole plates, clamps, embedded parts.	One (1) Set
3	Down shop leads complete with conductors, fixtures, insulators etc.	One (1) Set
4	Lifting Beam (350 Tonnes)	One (1) No.
5	All consumables for site assembly and erection etc.	Lot

19.11.1.2 Tools, Tackles and Spares

Sl. No.	Description	Quantity
1	Spares for the cranes	One (1) Set
2	Tools, special tools for maintenance	One (1) Set

19.11.1.3 Services

Sl.No.	Description	Quantity
1	Transport up to site	One (1) Lot
2	Storage and preservation at site.	One (1) Lot
3	Site assembly, erection, testing and commissioning.	One (1) Lot
4	Operation and Maintenance till commissioning of all units.	One (1) Lot
5	Training	One (1) Lot

6	All other items implied as per the contents of the specification or otherwise required for completion of the equipment/work even though not explicitly mentioned.	One (1) Lot

19.11.2 For Butterfly Valve House Crane

19.11.2.1 Main Equipment and Accessories

Sl. No	Description	Quantity
1	60/15T capacity EOT Crane suitable to operate as and when required, complete with all accessories and slings.	One (1) No.
2	Runway rails complete with sole plates, clamps and embedded parts.	One (1) Set
3	Down shop leads complete with conductors, fixtures, insulators etc.	One (1) Set
4	All consumables for site assembly and erection.	One (1) Lot

19.11.2.2 Tools, Tackles and Spares

Sl. No	Description	Quantity
1	Spares for the cranes	One (1) Set
2	Tools, special tools and other devices for maintenance	One (1) Set

19.11.2.3 Services

Sl. No	Description	Quantity
1	Insurance and Transportation up to site	One (1) Lot
2	Storage and preservation at site until erection and commissioning.	One (1) Lot
3	Site assembly, erection, testing and commissioning.	One (1) Lot
4	Operation and Maintenance till commissioning of all BFVs.	One (1) Lot
5	Training	One (1) Lot
6	All other items implied as per the contents of the specification or otherwise required for completion of the equipment/work even though not explicitly mentioned.	One (1) Lot

19.11.3 For GIS Crane

19.11.3.1 Main Equipment and Accessories

Sl. No	Description	Quantity
1	EOT crane of 10T capacity suitable to operate as and when required, complete with all accessories and slings as detailed in the specifications.	One (1) No.
2	Runway rails of suitable size complete in all respect including fixing at site.	One (1) Set
3	Complete trolley runway with conductors, fixtures, insulations, etc. as per clauses.	One (1) Set
4	All consumables for site assembly and erection etc.	One (1) Lot

19.11.3.2 Tools, Tackles and Spares

Sl. No	Description	Quantity
1	Spares for the cranes	One (1) Set
2	Tools, special tools and other devices for maintenance	One (1) Set

19.11.3.3 Services

Sl. No	Description	Quantity
1	Insurance and Transportation up to site	Lot
2	Storage and preservation at site until erection and commissioning.	Lot
3	Site assembly, erection, testing and commissioning.	Lot

4	Training	Lot
5	All other items implied as per the contents of the specification or otherwise required for completion of the equipment/work even though not explicitly mentioned.	Lot

NB:

The capacity of the crane may be altered and should be in accordance with the maximum load to be lifted. The Bidder shall have to indicate the weight of the heaviest package to be lifted, justifying the capacity of the crane. Crane should meet all the requirements of erection and commissioning of generating units and Butterfly Valves.

19.12 Spare Parts

Recommended spare parts shall be supplied in accordance to clause 3 "Spare Parts and Tools" of General Technical Specifications. Mandatory spare parts to be supplied under this Chapter are as follows.

Sl. No	Description	Quantity
1	**POWER HOUSE EOT CRANE**	
1.1	**Main Hoist**	
	Wire rope	1 full length
	Set of brake lining, pad, motor, springs, seal kit, solenoid coil etc. complete with rivets etc. for each type of brake supplied	1 no.
	Electric motor	1 no. of each type
	Limit switches	1 no. of each type
1.2	**Auxiliary Hoist**	
i)	Wire rope	1 full length
ii)	Set of brake lining, pad, motor, springs, seal kit, solenoid coil etc. complete with rivets etc. for each type of brake supplied	1 no.
iii)	Electric motor	1 no. of each type
iv)	Limit switches	1 no. of each type
1.3	**Bridge drive**	
i)	Electric motor	1 no. of each type
ii)	Set of brake lining, pad, motor, springs, seal kit, solenoid coil etc. complete with rivets etc. for each type of brake supplied.	2 nos.
iii)	Limit Switches	1 no. of each type
1.4	**Trolley drive**	

Sl. No	Description	Quantity
i)	Set of brake lining, pad, motor, springs, seal kit, solenoid coil etc. complete with rivets etc. for each type of brake supplied	1 no.
ii)	Electric motor	1 no. of each type
iii)	Limit Switches	1 no. of each type
1.5	**Monorail**	
i)	Wire rope	1 full length
ii)	Electric motor	1 no. of each type
iii)	Limit switches	1 no. of each type
iv)	Set of brake lining, pad, motor, springs, seal kit, solenoid coil etc. complete with rivets etc. for each type of brake supplied	1 no.
1.6	**Other miscellaneous spares for complete crane including monorail:**	
i)	Circuit breaker of each type	1 no.
ii)	Printed circuit boards (with components)	1 no. of each type
iii)	Fuses including fast acting fuses used in thyristor circuits	2 nos. of each type
iv)	Indicating lamps/ LED	2 nos. of each colour (red, blue, green, amber, white etc.)
v)	Overload relays and time delay relay	1 no. of each type
vi)	Bearings for wheels, gear boxes, hooks, hoist drum and motors, for complete crane	1 no. of each type and size
vii)	Push button	2 nos. of each colour amber, white etc.) (red, blue, green)
viii)	Module (Rectifier/ MOSFET/Thyristor)	1 no. for each MH, AH, CT and LT
2	**BUTTERFLY VALVE HOUSE CAVERN EOT CRANE**	
2.1	**Main hoist**	
i)	Wire rope	1 full length
ii)	Set of brake lining, pad, motor, springs, seal kit, solenoid coil etc. complete with rivets etc. for each type of brake supplied	1 no.
iii)	Electric motor	1 no. of each type
iv)	Limit switches	1 nos. of each type

Sl. No	Description	Quantity
2.2	**Auxiliary hoist**	
i)	Wire rope	1 full length
ii)	Set of brake lining, pad, motor, springs, seal kit, solenoid coil etc. complete with rivets etc. for each type of brake supplied	1 no.
iii)	Electric motor	1 no. of each type
iv)	Limit switches	1 nos. of each type
2.3	**Bridge drive**	
i)	Electric motor	1 no. of each type
ii)	Set of brake lining, pad, motor, springs, seal kit, solenoid coil etc. complete with rivets etc. for each type of brake supplied	2 nos.
iii)	Limit Switches	1 no. of each type
2.4	**Trolley drive**	
i)	Set of brake lining, pad, motor, springs, seal kit, solenoid coil etc. complete with rivets etc. for each type of brake supplied	1 no.
ii)	Electric motor	1 no. of each type
iii)	Limit Switches	1 no. of each type
2.5	**Other miscellaneous spares for complete crane;**	
i)	Circuit breaker of each type	1 no.
ii)	Printed circuit boards (with components)	1 no. of each type
iii)	Fuses including fast acting fuses used in thyristor circuits	2 nos. of each type
iv)	Indicating lamps/ LED	2 nos. of each colour (red, blue, green, amber, white etc.)
v)	Overload relays and time delay relay	1 no. of each type
vi)	Bearings for wheels, gear boxes, hooks, hoist drum and motors for complete crane	1 no. each type and size
vii)	Push button	2 nos. of each colour (red, blue, green, amber, white etc.)

Sl. No	Description	Quantity
viii)	Module (Rectifier/ MOSFET/Thyristor)	1 no. for each MH, CT and LT
3	**GIS EOT Crane**	
3.1	**Hoist**	
	Wire rope	1 full length
	Set of brake lining, pad, motor, springs, seal kit, solenoid coil etc. complete with rivets etc. for each type of brake supplied	1 no.
	Electric motor	1 no. of each type
	Limit switches	1 nos. of each type
3.2	**CT and LT motion**	
i)	Electric motor	1 no. of each type
ii)	Set of brake lining, pad, motor, springs, seal kit, solenoid coil etc. complete with rivets etc. for each type of brake supplied	2 nos.
iii)	Limit Switches	1 no. of each type
3.3	**Other miscellaneous spares for complete crane**	
i)	Circuit breaker of each type	1 no.
ii)	Printed circuit boards (with components)	1 no. of each type
iii)	Fuses including fast acting fuses used in thyristor circuits	2 nos. of each type
iv)	Indicating lamps/LED	2 nos. of each colour (Red, blue, green, amber, white etc.)
v)	Overload relays and time delay relay	1 no. of each type
vi)	Bearings for wheels, gear boxes, hooks, hoist drum and motors for complete crane	1 no. each type and size
vii)	Push button	2 nos. of each colour (Red, blue, green, amber, white etc.)
viii)	Module (Rectifier/MOSFET/Thyristor)	1 no. for each hoist and cross travel

Besides above, the Contractor shall recommend any additional spare parts, which in his opinion are necessary for satisfactory operation of the system. However, the procurement of these recommended spares shall be at the discretion of the purchaser. The additional recommended spare parts shall be indicated in the Data Sheets of Volume-6.

19.13 Guaranteed and Other Technical Particulars

The Contractor shall follow the Guaranteed & Other Technical Particular requirements specified separately in Data Sheets of Volume-6.

19.14 Tools and Instruments

The Contractor shall supply all necessary tools and Instruments etc. for installation, repair and maintenance in accordance to clause. 3.2 "Tools and Instrument" of General Technical Specification.

19.14.1 Special Tools

The Contractor shall list and supply all special tools. List of such tools including their make and detailed specification, shall be submitted for acceptance by the Employer besides the following special tools:

i) Two (2) sets of special tools for maintenance and service seal replacement,

ii) Two (2) sets nitrogen leak detector.

19.15 Quality Control and Assurance

The Contractor shall submit detailed Quality Assurance Plan and Inspection Schedule for Employer's review and approval in accordance to clause 12 of General Technical Specification.

19.16 Deputation of Engineers for witness of Tests, Inspection & Training

The Employer's representatives shall be deputed for the following purposes.

Sl. No.	Description	Batch	No of Days	No. of Engineers and Technicians
1	Training at the plant and design office	1	3	2 Engineers 4 Technicians
2	Shop Inspection and Test	As and when required for inspection and test		

The training of employer's personnel shall be as specified in clause 11.0 "Training of Employer's Personnel" of General Technical Specification.

19.17 Deviations from Specifications

All deviations from these specifications shall be separately listed in the requisite Performa of the bid document, in the absence of which, it will be presumed that the provisions of the specifications are fully complied with by the bidder. However, the deviations, which are better than the specifications shall be considered by the purchaser.

19.18 Completeness of Contract

Any fittings, accessories or apparatus required for successful commissioning though may not have been specifically mentioned in the specification but are usually necessary for the completeness of the works shall be deemed to be included in the specification and shall be supplied by the bidder without any extra cost to the purchaser.



19.19 Employer's Specifications at Erection Bay

Sl. No.	Item	Unit	Data
	General		
1	Designation: electrically operated travelling crane for		**Erection bay**
2	Number Required:		2 Nos.
3	Tandem Operation		YES
4	Location In Hazardous Area:		NO
5	Hazardous Area Classification:		As per IS 5572 Zone 5
6	Location:		Indoor
7	Crane Classification: As Per IS 13834		
8	Mechanism Class: As Per IS 13834		M5-Mechanical M5-Electrical
9	Special Service Conditions If Any		
10	Operating Voltage/Frequency At Crane Locations		415 V & 50 Hz
11	Design Std.		IS-3177 & IS-807
	Design Data		
12	Type:		Overhead - Double Girder
13	Type Of Girder:		BOX
14	Capacity:		
14.1	Main Hoist:	Ton	200 (Ref Note 4)
14.2	Auxiliary Hoist:	Ton	40 (Ref Note 4)
14.3	Quantity	Nos	2
15	SPAN:	m	19.5 (Ref Note 4)
16	Runway Length:	m	120 (Ref Note 4)
17	Range Of Lifting For:		(Ref Note 4)
17.1	Main Hoist:		
i)	Elevation From	M	797.00
ii)	Elevation To	M	772.50
17.2	Auxiliary Hoist:		
i)	Elevation From	M	797.00
ii)	Elevation To	M	772.50
18	Operating Floor Elevation: (Crane Operation Shall Be Possible By Radio Remote From Lowest Elevation)	M	784.00
19	Type Of Hook:		
19.1	Main:		RAMSHORN As Per IS 5749
19.2	Auxiliary:		Plain Shank As Per IS 15560
20	Provision Of Standard Depressed Type Safety Latch For Main & Auxiliary Hooks		YES
21	Speeds: Main / Creep		
22	Main Hoist	M/min	1.2.0 / 1.5
23	Aux. Hoist	M/min	8.0/1.5
24	Long Travel	M/min	20.0/2
25	Cross Travel	M/min	15 / 1.5

Sl. No.	Item	Unit	Data
26	Method of Operation:		Cabin and Radio Remote Control
27	Inching And Plugging Controls:		
28	Inching Control Required For: Hoisting / Long Travel / Cross Travel		YES
29	Plugging Control Required For: Hoisting / Long Travel / Cross Travel		YES
30	Design Seismic Co-Efficient For The Crane:		As Per Project Information, Of The Enquiry Specification.
31	Long Travel Walkway Required On Either Side		YES BY OTHERS
32	Maintainence Walkway On Bridge Required: (Applicable For Double Girder Crane)		YES
33	Buffers Required For Trolley And Long Travel Movement		YES
	Materials And Codes Of Construction		
34	Bridge Girder:		AS PER IS 2062
35	End Carriage:		AS PER IS 2062
36	Rope Drums And Sheaves: (Note 1)		AS PER IS 3177
37	Steel Wire Rope:		AS PER IS 2266
38	Core:		FIBRE/STEEL
39	Gears And Pinions: (Note 1)		Spur/ Helical/ Worm As Per IS 4460/IS 7443 /AGMA STANDARDS
40	Bearings:		Ball Or Roller Type Anti-Friction Bearings As Per IS 5669/IS 5692/IS 5932/IS 5935
41	Shafts And Axles:		CARBON STEEL
42	Lifting Hooks:		Forged And Heat-Treated Alloy Steel/Carbon Steel As Per IS15560
43	Long And Cross Travel Wheels: (Note 1)		Rim Toughened, Heat Treated Cast Steel Or Wrought Steel, Carbon Steel As Per IS 4164/ IS 5749
44	Crane Rails:		IS 3443
45	Lubrication (Bearings): Lubrication (Gear Box):		Life Lubricated/Centralised Grease Lubrication Centralised Grease Lubrication With Hand Operated Grease Pump/ Oil

Sl. No.	Item	Unit	Data
			Splash Lubricated/Life-Time Grease Lubricated.
	Brakes		
46	Main Hoist:	(1+1)	Fail Safe Electro Magnetic (DCEM) And Electrohydraulic Thruster
47	Auxiliary Hoist:	(1+1)	Fail Safe Electro Magnetic (DCEM) And Electrohydraulic Thruster
48	Long Travel And Cross Travel:	(1+1)	Fail Safe Electro Magnetic (DCEM) And Electrohydraulic Thruster
49	Requirement Of Storm Brake: (In Case Of Outdoor Crane)		Not Applicable
50	A Hand Release Lever To Be Provided For Manual Release Of Brake.		
	Electricals (Note 2)		
51	Motors:		BY VENDOR
52	Starters:		VVVF drives for above 30 KW motors
53	Control Panel Mounting:		Mounted On Crane Bridge
54	Runway Conductors:		PVC Shrouded Copper Bus Bar
55	Cross Travel Conductors:		Flexible Trailing Cable
56	Down Shop Lead Conductors /Collectors		By Vendor
57	Power Conductors:		Minimum 6 Mm^2 Copper/Aluminium
58	Control Cable:		Minimum 2.5mm^2 Stranded Copper
59	Lighting Cables:		Minimum 2.5mm^2 Single Core Stranded Copper
	Erection		
60	Erection Of Crane Rail With Fixture:		By Vendor
61	Erection Of Runway Conductors With Fixtures:		By Vendor
62	Supply Of Lifting Attachments If Any:		By Vendor
63	Type And Capacity Of Lifting Attachment Required		Equalizing Beam For Erection Crane.
	Companion Specifications		
64	MOTORS:		Refer Section D21 AND AS PER IS 3177
65	Control Cabinets:		REFER SECTION D20
66	Limit Switches:		
66.1	Main Hoist		YES
66.2	Auxiliary Hoist		YES
66.3	Long Travel		YES
66.4	Cross Travel		YES
67	Battery Back Up System:		YES

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Sl. No.	Item	Unit	Data
68	Load Indication And Limiting Device:		YES
	TESTS AND INSPECTION		
69	As Per Section E6 Minimum Inspection Requirement Of EOT		
70	Overload Test		
71	For Hoisting:		125% Of Specified Load
72	For Crane Travel Motion:		125% Of Specified Load
73	Test Loads Along With Slings And Craddle Arrangement		By Vendor
74	Deflection Of Main Girders With Specified Load At The Centre As Per IS 807:		MAXIMUM 1/ 900 OF SPAN
75	Speed Check For All Motions:		YES
76	Insulation Test For All Electrical Equipment:		YES
77	**Performance Guarantees**		
	Capacity:	T	No Negative tolerance
78	Lift:	M	No Negative tolerance
79	Speeds For All Motions:	MPM	± 10%
	Loading Penalty		
80	Power:	Nu. PER KW	
	List Of Approved Sub-Vendors		
81	Motors		ABB, ALSTOM, BHEL, CGL, KEC, SIEMENS
82	Brakes		ELEKTROMAG, OMEGA CONTROLS, SPEED-O-CONTROL, STROM KRAFT,
83	Limit Switches		ELECTROMAG, OMEGA CONTROLS, STROM KRAFT
84	Bearings		FAG, NTN, SKF
85	Hooks		KARACHIWALA, STEEL FORGING
86	Wire Ropes		FORT WILLIAM, USHA MARTIN
87	VVVF Drives		L&T, ABB, SIEMENS
88	Radio Remote Control		TELECRANE or equivalent
89	Contractors		SIEMENS, L&T, BCH
90	Push Buttons		SIEMENS, L&T, AIRON

NOTES:

1. Materials of construction indicated are for cranes operating in non-hazardous area. For the cranes operating in hazardous area, all contact parts shall be of dissimillar materials. For example: bronze to steels, brass to steel etc.
2. All electrical equipment shall be suitable for specified hazardous zone as per IS 5572, whenever it is required for.
3. Tests other than TCE-186-11 STD and as specified in the project requirements shall also be performed.

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Sl. No.	Item	Unit	Data
4.	The span, bay length and lift shall be as per the powerhouse layout & capacity shall be as per heaviest lifting equipment weight will be finalized during detailed engg, subject to owner approval. The capacity indicated in tender is minimum requirement.		

19.20 Employer's Specification for EOT at GIS Building

Sl. No.	Item	Unit	Data
	Location		**GIS Building**
	General		
1	Designation: Electrically Operated Travelling Crane For		**GIS Building**
2	Number Required:		1 No
3	Location In Hazardous Area:		NO
4	Hazardous Area Classification:		AS PER IS 5572 ZONE 2
5	Location:		INDOOR
6	Crane Classification: AS PER IS 13834		
7	Mechanism Class: AS PER IS 13834		M5-Mechanical M5-Electrical
8	Special Service Conditions If Any		
9	Operating Voltage/Frequency At Crane Locations		415 V & 50 Hz
10	Design Std.		IS-3177 & IS-807
	Design Data		
11	Type:		Overhead - Double Girder
12	Type & Size Of Girder		By Bidder
13	Capacity:	T	10 (Ref Note 4)
14	Quantity	Nos	1
15	Span:	M	15.2 (Ref Note 4)
16	Runway Length:	M	109 (Ref Note 4)
17	Height Of Lift	M	19 (Ref Note 4)
18	Operating Floor Elevation:	M	GIS Building floor
19	Type Of Hook:		Plain Shank As Per IS 15560
20	Provision Of Standard Depressed Type Safety Latch For Main & Auxiliary Hooks		YES
21	Speeds:		MAIN
21.1	Hoist	M/min	1.2
21.2	Long Travel	M/min	15
21.3	Cross Travel	M/min	10
22	Method Of Operation:		Movable Pendant Push Button
23	Inching And Plugging Controls:		
23.1	Inching Control Required For: Hoisting / Long Travel / Cross Travel		YES
23.2	Plugging Control Required For: Hoisting / Long Travel / Cross Travel		YES
24	Design Seismic Co-Efficient For The Crane:		As Per Project Information, Section B Of The Enquiry Specification.
25	Long Travel Walkway Required On Either Side		No By Purchaser / Others

Sl. No.	Item	Unit	Data
	Location		**GIS Building**
26	Maintenance Walkway On Bridge Required: (Applicable For Double Girder Crane)		NO
27	BUFFERS REQUIRED FOR TROLLEY AND LONG TRAVEL MOVEMENT		NO
	Materials and codes of construction		
28	Bridge Girder:		AS PER IS 2062
29	End Carriage:		AS PER IS 2062
30	Rope Drums And Sheaves: (Note 1)		AS PER IS 3177
31	Steel Wire Rope:		As Per IS 2266
31.1	Core:		Fibre/Steel
32	Gears And Pinions: (Note 1)		SPUR/ HELICAL/ WORM AS PER IS 4460/IS 7443 /AGMA STANDARDS
33	Bearings:		Ball Or Roller Type Anti-Friction Bearings As Per IS 5669/IS 5692/IS 5932/IS 5935
34	Shafts And Axles:		CARBON STEEL
35	Lifting Hooks:		Forged And Heat-Treated Alloy Steel/Carbon Steel As Per IS15560
36	Long And Cross Travel Wheels: (Note 1)		Rim Toughened, Heat Treated Cast Steel Or Wrought Steel, Carbon Steel As Per IS 4164/ IS 5749
37	Crane Rails:		IS 3443
38	Lubrication (Bearings): Lubrication (Gear Box):		Life-Lubricated/Centralised Grease Lubrication Centralised Grease Lubrication With Hand Operated Grease Pump/ Oil Splash Lubricated/Life-Time Grease Lubricated.
	Brakes		
39	Hoist:	(1+1)	Fail Safe DCEM Brake For Underslung Crane
40	Long Travel And Cross Travel:	1+1)	Fail Safe DCEM Brake For Underslung Crane
41	Requirement Of Storm Brake: (In Case Of Outdoor Crane)		NOT APPLICABLE
	A Hand Release Lever To Be Provided For Manual Release Of Brake.		
	ELECTRICALS (NOTE 2)		
42	Motors:		By Vendor

Sl. No.	Item	Unit	Data
	Location		**GIS Building**
43	Starters:		By Vendor
44	Control Panel Mounting:		Mounted On Crane Bridge
45	Runway Conductors:		PVC Shrouded Copper Bus Bar
46	Cross Travel Conductors:		Flexible Trailing Cable
46.1	Down Shop Lead Conductors /Collectors		By Vendor
47	Power Conductors:		Minimum 6 Mm^2 Copper/Aluminium
48	Control Cable:		Minimum 2.5mm^2 Stranded Copper
49	Lighting Cables:		Minimum 2.5mm^2 Single Core Stranded Copper
	Erection		
50	Erection Of Runway Conductors With Fixtures:		By Vendor
51	Supply Of Lifting Attachments If Any:		By Vendor
52	Type And Capacity Of Lifting Attachment Required		By Vendor
	Companion Specifications		
53	Motors:		As per IS 3177
54	Control Cabinets:		Required
55	Limit Switches:		
55.1	Hoist		YES
55.2	Long Travel		YES
55.3	Cross Travel		YES
56	Battery Back Up System:		YES
57	Load Indication And Limiting Device:		YES
	Tests And Inspection		
58	AS PER TCE.M4-186-11		
59	Overload Test		
59.1	For Hoisting:		125% OF SPECIFIED LOAD
59.2	For Crane Travel Motion:		125% OF SPECIFIED LOAD
60	Test Loads Along With Slings And Craddle Arrangement		BY VENDOR
61	Deflection Of Main Girders With Specified Load At The Centre As Per IS 807:		MAXIMUM 1/1000 OF SPAN
62	Speed Check For All Motions:		YES
63	Insulation Test For All Electrical Equipment:		YES
	Performance Guarantees		
64	Capacity:	T	No Negative Tolerance
65	Lift:	M	No Negative tolerance
66	Speeds For All Motions:	MPM	± 10%
	LOADING PENALTY		

Sl. No.	Item	Unit	Data
	Location		**GIS Building**
67	POWER:	Nu. Per KW	
	List Of Approved Sub-Vendors		
68	Motors		ABB, ALSTOM, BHEL, CGL, KEC, SIEMENS
69	Brakes		ELEKTROMAG, OMEGA CONTROLS, SPEED-O-CONTROL, STROM KRAFT,
70	Limit Switches		ELECTROMAG, OMEGA CONTROLS, STROM KRAFT
71	Bearings		FAG, NTN, SKF
72	Hooks		KARACHIWALA, STEEL FORGING
73	Wire Ropes		FORT WILLIAM, USHA MARTIN
74	Vvvf Drives		L&T, ABB, SIEMENS
75	Radio Remote Control		TELECRANE or equivalent
76	Contractors		SIEMENS, L & T, BCH
77	Push Buttons		SIEMENS, L & T, AIRON

NOTES:

1. Materials of construction indicated are for cranes operating in non-hazardous area. For the cranes operating in hazardous area, all contact parts shall be of dissimilar materials. For example: bronze to steels, brass to steel etc.
2. All electrical equipment shall be suitable for specified hazardous zone as per IS 5572, whenever it is required for.
3. Tests other than TCE-186-11 STD and as specified in the project requirements shall also be performed.
4. The span, bay length and lift shall be as per the powerhouse layout & capacity shall be as per heaviest lifting equipment weight will be finalized during detailed engineering, subject to owner approval. The capacity indicated in tender is minimum requirement.

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CHAPTER 20: FIRE PROTECTION SYSTEM

20.1 Scope of Work

The scope of work for the fire protection system shall be complete with required equipment systems as per IS and NFPA Guidelines but not limited to the following. Scope of work includes Design, supply, installation, testing, commissioning, training of employer's personals and handing over of Fire protection system for entire Power Plant and its auxiliary building as per NFPA520/851.

The complete fire protection system shall be as per the following drawings enclosed but not be limited to the scope shown. It is the responsibility of the successful Bidder to ensure completeness of the system to meet NFPA & IS requirements.

Bidder shall provide the reference list of installations along with details of

Obtaining approval from statutory authority.

Fire protection system is considered for the complete project. The Transformers and Reactor will be provided with automatic high velocity water spray system.

As per CEA guidelines, in underground powerhouse, generator protection shall be water spray type as release of CO2 in underground powerhouse may be hazardous. Alternatively for generator protection, an Inert gas fire suppression system is considered.

Hose cabinets/ hydrants are considered in the powerhouse cavern, transformer cavern and pothead yard. To cater the fire protection requirements, an overhead fire water tank and pumping system is envisaged as per NFPA requirements.

20.1.1 Hydrant System

Hydrant System for entire area of Hydroelectric Project. This will include the Powerhouse other auxiliary and Pothead yard.

20.1.2 High Velocity Water Spray (HVWS) System

High Velocity Water Spray (HVWS) system shall be provided for Generator step up transformers (GT), Station auxiliary transformers (SAT). The list of transformers to be covered by HVWS systems are indicated in Appendix – 1 enclosed. HVWS system shall also be provided for Governor & MIV high pressure oil supply unit.

20.1.3 Medium Velocity Water Spray (MVWS) System

Medium Velocity Water Spray System (MVWS) shall be provided for all cable galleries/vault, within powerhouse building.

20.1.4 Fire Detection and Alarm (FDA) System

Fire Detection and Alarm System (FDA) shall be provided for all Floor (MIV, Turbine, Generator and Machine Hall) along with GIS Hall, Control rooms, Switchgear rooms Bus Cable tries, Office room, Conference room and etc. within powerhouse building

20.1.5 Clean Agent Gas Extinguishing System

i) This system shall conform to NFPA-2001 and shall be provided for the central Control Room, GIS Control room.

ii) Clean gas system shall be provided with 100% standby reserve supply of containers filled with the agent and duly connected to the piping manifold.

20.1.6 Portable Fire Extinguishers

Portable Fire Extinguishers shall be provided covering all the areas of the Project. Type, Capacity and no of extinguishers shall be as per standard and shall be submitted for Owner's approval.

20.2 Design Criteria

20.2.1 Hydrant System

This Plant falls under Light hazard classification as per IS. The hydrant system shall cover all the areas of the plant. The system shall consist of a network of piping installed underground and above ground around areas to be protected, Section isolation valves, hydrant valves (external / internal) with isolation valves, Water monitors, hoses, hose cabinets, couplings, branch pipe & nozzles (made by Bronze). The maximum allowable velocity of flow in Hydrant & spray system pipes up to deluge valve shall be 2.8m/s. External hydrants shall be located all around the periphery of buildings and internal hydrants shall be provided at each floor landing of staircases and also as required to cover the powerhouse inside area.

Hose cabinets housing standard accessories like hoses of suitable fitted length, couplings, branch pipes & nozzles shall be provided at each hydrant points. The source of water required for hydrant systems will be from the fire water storage tank.

20.2.2 High Velocity Water Spray (HVWS) System

HVWS system shall cover all the areas as mentioned in clause no. 16.1.2. The HVWS system for transformers shall be automatic. However, provisions shall also be made to operate the system manually through local push button actuation. The system shall automatically detect, control and extinguish any outbreak of fire and simultaneously give audible alarm.

The HVWS system shall consist of a network of rings fitted with nozzles for water projection around the equipment to be protected. The water supply to the spray system shall be controlled by wet pilot type deluge valve, which shall be operated hydraulically and is normally closed by water pressure. A bypass line along with a fast-acting butterfly valve shall be provided for deluge valve, so that the butterfly valve can be kept closed and operated manually in the event of fire, if there is any malfunction of deluge valve.

In case of transformers, the detection system shall be of water filled detection system consisting of heat sensing detectors of fusible type (Quartzoid bulbs). In the event of the surrounding temperature increases more than the rated temperature of detector, the detector bulb collapses and consequently there will be a drop in pressure in the detection network. This drop in pressure shall open the deluge valve and water starts projecting out from the projectors. Remote / manual actuation push button units shall also be provided.

Water for the HVWS system shall be tapped off from hydrant header. The maximum allowable velocity in spray system pipes up to deluge valve shall be 2.8m/s

20.2.3 Medium Velocity Water Spray (MVWS) System

The medium velocity spray system shall be provided for all the areas. In order to avoid total flooding of the are in the event of fire in a particular zone, the area shall be divided into number of zones. Each zone shall have separate water supply network controlled by a deluge valve. The fire in the cable vault/gallery shall be detected by a detection system, which will give an electrical signal for the operation of the respective deluge valve. In the event of fire in zone, the deluge valve of corresponding zone and those of adjacent zone on either side shall also be opened. Water required for this system shall be tapped off from hydrant header.

The cable galleries/vault shall have number of rows of cable trays and each row will have number of tiers of cable trays. Each of the cable rows shall be provided with a network of water distribution piping and nozzles. The distribution network shall consist of distribution header for each row of cable tray and on these headers drop pipes located at an interval not exceeding 3 meters shall be provided so as to cover all the tiers.

The source of water required for MVWS system will be tapped off from the hydrant header. The maximum allowable velocity in spray system pipes upto deluge valve shall be 2.8m/s.

20.2.4 Fire water storage system

One overhead tank of required capacity will be provided by the owner at higher elevation as

required by the contractor. (The water supply should last at least 2 hours at a pressure of 7kg/cm2).

Suitable capacity of Overhead Fire water tank size shall be provided by Bidder. The Overhead tank filling arrangement will be done from Owners.

20.2.5 Clean Agent Gas Extinguishing System

i) This system shall conform to NFPA-2001 and shall be provided for the following:

a) **PLCC Control room,**

b) **GIS Control room,**

ii) Clean agent gas extinguishing system shall be provided with 100% standby reserve supply of containers filled with the agent and duly connected to the piping manifold.

iii) The Clean agent gas extinguishing system shall be proven & well established for the type of specified operation.

iv) Bidder shall provide the reference list of installations along with details of obtaining approval from statutory authority.

v) Each bank of the main standby cylinders is proposed with an independent pilot cylinder for operation. A common manifold of schedule 80 CS pipes is proposed for each of the main and standby cylinders and connected through a check valve. The nozzles are spaced and located in the respective protected areas as per the requirement and connected to the manifold. The pipes shall be seamless conforming to ASTM A 106 Gr. B Schedule 80 and galvanized as per IS code.

vi) Detection system provided below false ceiling, false floor as applicable and above false ceiling shall consist of smoke detectors of both Multi sensor type and photo-electric type. Cross-zoning of Multi sensor with photo electric type smoke detectors shall be done in such a way that the fire (either above false ceiling or below false ceiling) is detected by at least one detector of each type to operate the automatic inert gas releasing system. However, alarm will be annunciated even if one type of detector has detected the fire. Provision shall be kept in annunciation-cum-control panel to stop the release of inert gas i.e discharge inhibition even if both type of detectors have given the fire signal. Also, manual release of inert gas must be possible even if in the absence of signal from smoke detectors. Automatic/manual release of inert gas shall be preceded by an alarm located in the concerned areas for alarming the personal from the occupancy and for this purpose 120 seconds time shall be given. Further potential free contacts shall also be provided to enable the switching off the air-conditioning system and other system as necessary at the time of release of inert gas.

vii) In the event of fire, the signal from detection system shall be made use of to cut off the power supply to the panels.

a) **Design, Manufacture and installation of clean agent gas extinguishing system shall be in strict accordance with NFPA-2001 and certified by UL/FM/VDS/NMRI etc.**

b) **The system shall consist of clean agent gas cylinders, cylinder mounting accessories, cylinder manifold, pressure reducing devices, cylinder valves, directional valves, discharge piping, nozzles, automatic operating devices, manual actuation devices/abort switches, associated fire detection/alarm system, audio-visual safety warning devices, instrumentation, associated control system, panels etc.**

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20.2.6 Design Philosophy

i) Minimum design concentration shall be based on type of clean agent gas fire extinguishing system used.

ii) The complete volume of the rooms including the above false ceiling shall be considered for estimation of quantity of gas and containers.

iii) When determining the gas quantity, the leakage losses from the enclosure shall be taken into account by the supplier. Further volume of re-circulating type air conditioning system & its ductwork (at least up to the automatic fire dampers of the ducts) shall be considered as a part of the total volume of that the design concentration achieved throughout the hazard area. Further gas quantity shall be adjusted for ambient pressure conditions.

iv) Individual Storage system or common Storage system with directional valves for multiple zones shall be provided. If Common storage system is considered, the total primary supply is equivalent to the requirement of largest area/room and such rooms / areas are perfectly separated from each other by means of walls of required fire rating shall be provided. Reserve system capacity shall be same as primary supply.

v) Both the main & reserve supply cylinders shall be permanently connected to the distribution piping through manifold and arranged for easy changeover from the panel. Suitable switches be provided for "Normal/Standby" supply selection.

vi) The discharge time period shall be such that the design concentration is achieved within 60 seconds. The flow calculations shall establish these criteria.

vii) The quality of gas shall conform to relevant design standard such as NFPA-2001 or as specified by listing authorities.

20.2.7 Storage Containers

i) All the storage containers shall be provided under an enclosure. It shall not be kept open to atmosphere.

ii) The storage containers shall be securely installed as per the listed installation manual with a provision for convenient individual servicing and container weighing. Such servicing or weighing shall be possible without shutting down the system.

iii) Automatic means such as check valves shall be provided to prevent gas loss if the system is operated when any containers are removed for maintenance.

iv) The storage containers shall not be charged to a fill density or super pressurization level different from the manufacturer's listing.

v) The design pressure for storage cylinders shall be suitable for the maximum pressure developed at 55ºC and shall be designed to meet the requirements in NFPA-2001.

vi) All cylinders shall be approved by CHIEF CONTROLLER OF EXPLOSIVES – INDIA.

vii) The storage cylinders shall have accessories such as pressure gauges/switches, liquid level indicators (if applicable) refilling connections, relief devices (if applicable) etc. A reliable means of indication other than weighting shall be provided to determine the pressure in cylinders.

viii) All the pressure gauges/switches, manifold connections etc. shall be easily removable for servicing/maintenance without any loss of gas.

20.2.8 Distribution

i) Piping fittings, pressure relieving device (if any) shall be designed for the maximum design pressure of the system and shall conform to the requirements of NFPA-2001 or as specified by listing authorities.

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ii) Discharge nozzles along with deflector shields shall be listed for the intended use including the flow characteristics and area of coverage and quantity & design shall be such that complete quantity of gas is uniformly distributed throughout the hazard volume within the specified discharge time without disturbing the ceilings, lighting fixtures etc.

iii) The fire detection system to be employed shall be as specified elsewhere. Operating devices shall be by mechanical, electrical and pneumatic mean conforming to NFPA-2001. The power supply to electrical actuators shall be backed up with reliable battery supply. Such batteries shall be charged automatically by battery chargers. Power supply be taken from the Fire detection/Alarm system panels of the respective units. Required annunciations such as "Gas released", "Failure of automatic actuation" etc. shall be exhibited in the fire alarm panel.

iv) The number of pilot cylinders shall be as per the listed design manual.

v) Facility for manuals release of gas through push buttons be provided along with selection facility of "Auto/Manual" from the panel.

vi) In addition to this, local manual release through lever operation shall also be provided near the cylinder banks.

vii) All manual – operating devices shall be identified to the hazard they protect.

viii) Manual abort switches shall be provided for each of the area/zone and the same shall be provided as per NFPA-2001 or as specified by listing authorities.

ix) The gas releasing devices at cylinder outlets shall be or re-usable type after discharge at any instant.

x) Supervision of automatic actuation devices, power supply, manual actuation circuits and complete wiring shall be provided through control system/panel, and the healthiness shall be reported or indicated in the panel automatically. Complete control system shall be listed and approved by UL/FM/VDS/LPC.

20.2.9 Safety

i) All the safety requirements recommended in NFPA-2001 or as specified by listing authorities shall be incorporated in the installation.

ii) Appropriate warning signs shall be fixed outside of those areas protected by the system and also in areas where the gas may spread indicating clearly the hazard associated with the system such as noise, turbulence cold temperature, physiological effects on personnel etc.

iii) Apart from written warnings signs, audio-visual type warning signs (i.e.) hooters & strobe lights shall be provided for pre-discharge and post-discharge activity. The sounder shall have selectable tone options.

iv) The gas shall be discharged after a set time delay or receiving signal from the fire detection system. The duration of the timer shall be up to a range of 0-5 minutes settable (adjustable in 1 minute variation) at site after conduction test to find out the duration for evacuation of the personnel from the area.

v) To prevent the loss/release of gas automatically or manually during maintenance, the system shall have the facility of "LOCKOUT". The status of the system lockout condition shall be annunciated audio visually in the panel

20.3 Specific Mechanical Requirements

20.3.1 Design and Performance Requirements (Hydrant and Spray system)

i) The complete system offered shall conform to the regulations of National Fire Protection Association (NFPA) and IS.

ii) All the equipment shall be designed to operate satisfactorily and meet all the requirements. The equipment shall be designed and manufactured in accordance with best engineering practices and shall have been proven to be suitable for the intended purpose.

iii) The hydrant system shall be designed such that opening of any of the hydrant valves in the system result in the automatic supply of water and sufficient pressure at hydrant valve to produce satisfactory hose stream for fighting the fire.

iv) The automatic fire protection system shall come into operation at the earlier stages of fire around the equipment to minimise damages and to prevent spread of fire to adjacent areas.

20.3.2 Clean Gas Extinguishing system

i) System design, working plans, flow calculations etc. shall be prepared in line with the NFPA-2001 or as specified by listing authorities and shall be approved by Owner. The system flow calculations shall be performed using a calculation listed or approved by UL/FM/VDS/LPC/NMRI.

ii) Calculations shall be provided to prove that the area is not pressurized, and extinguishing capability is not affected due to provided ventilation of that area.

iii) After installation, the complete system shall be inspected and tested as per the recommendations of Chapter – 4 and relevant Clauses of Appendix – A of NFPA-2001.

iv) The performance test of the system shall be carried out by releasing the agent gas in a selected area and parameter shall be measured. All equipment, refilling of gas after test, instruments etc shall be provided.

20.4 Drawings, Documents and Design Calculations

20.4.1 Design memorandum

The Contractor shall submit to Employer a design memorandum prepared the Design basis of Fire Protection and Detection system.

20.4.2 Drawings and documents

The Contractor shall submit all the drawings and documents to Employer to get the Approvals.

20.4.3 Design Calculations

The Contractor shall submit the design calculation for approval.

i) Sizing of Overhead water tank capacity,

ii) Calculation for selecting the HVWS and MVWS.

iii) Pipe Sizing & Routing, Hydrants (Internal & External).

The Contractor shall also provide other calculations as required by the Employer for his approval of the Contractor's design.

20.5 Test, Delivery, Installation and Commissioning

20.5.1 Shop Tests

The Hydrant cabinets, Deluge Valves, Filters, Detection items, Cables, Panels and Pipes & Fittings along with support channels etc. shall be routine tested as per relevant IEC/IS and international code for NFPA & IS. The contractor is required to submit routine test certificates of the equipment. Copies of the type test certificates in respect of the similar equipment supplied in the past for hydro projects would also need to be supplied.

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20.5.2 Field Tests

The Contractor shall follow the requirements of Delivery, Installation and commissioning elaborated in the Volume 1.

20.5.3 Field Tests

After installation, Fire Protection & Detection systems shall be field tested for operational tests as per the intended requirements and leakage tested. If the system shall be tested in sections, the same applies for each section.

All necessary materials and labour for performing the entire required test shall be provided by the contractor.

The contractor shall prepare and hand over to the Employer details of all test results in a report in a mutually agreed format.

20.6 Installation & Commissioning

The contractor shall furnish all labour, supervision, tools, supplies, bracing, spiders, shims and supports and all other provisions or materials necessary to assemble, erect, install, test and commission the equipment in a thorough workman like manner following the best modern practices. The equipment and all its components shall be placed with great care and accuracy and shall be aligned correctly to provide an installation consistent with the close tolerances used in the erection of modern equipment.

The proper elevations and centerlines to which equipment is to be set shall be established by the contractor.

All installation of Fire Protection & Detection Cabling & Piping Complete system shall be done by skilled workers in a workmanlike manner. Pipe fixtures shall be spaced according to accepted standards and provision made for thermal expansion and contraction of piping. Before installation all system components shall be checked for cleanliness.

20.7 Schedule of Requirement

The scope of supplies and services shall be as per various clauses of the technical specifications and supplier shall be responsible to ensure completeness of supplies and services even if these are not fully covered under this clause.

Any item of supply not explicitly listed but otherwise implied by the contents of the specification or essential for smooth operation of the equipment shall be construed as forming part of the supply and no additional charges shall be payable for the same.

The broad schedule of requirements is given in clause 16.1 “Scope of Work”.

20.8 Spare Parts

Recommended spare parts shall be supplied in accordance to clause 3 “Spare Parts and Tools” of General Technical Specifications. Specified spare parts to be supplied under this Chapter are as follows.

Sl. No	Description	Quantity
1	Automatic fire detectors, manual call points & response indicators, smoke detectors.	10% of the total number supplied for each type with minimum 2 Nos.
2	Signal distribution modules, signal conditioning modules and input/output modules	10% of each type of Module or minimum one, whichever is higher.
3	Processor module, communication module, power supply module, memory module and any other module.	10% of each type of Module or minimum one, whichever is higher

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4	Push buttons, indicators, indicating lamps, selector switches relays.	10% of each type of Module or minimum one, whichever is higher.
5	Connectors for prefab cables – male & female end	2 no. in each type
6	Field instruments, transmitters, limit switches, Proximity switches, interposing relay, MCB, relay, timer or any other instrument / item supplied.	10% of each type of Module or minimum one, whichever is higher
7	Fuses of each type & rating	2 Nos or 30% whichever is higher.
8	Terminals of each type	10 nos.
9	Coils, gaskets, diaphragm, o' rings	1 no. of each type and size
10	Plunger, seat	1 no. of each type and size

Besides above, the Contractor shall recommend any additional spare parts, which in his opinion are necessary for satisfactory operation of the system. However, the procurement of these recommended spares shall be at the discretion of the purchaser. The additional recommended spare parts shall be indicated in the Data Sheets of Volume-6.

20.9 Guaranteed & Other Technical Particulars

The Contractor shall follow the Guaranteed & Other Technical Particular requirements specified separately in Technical Data Sheets.

20.10 Tools and Instruments

The Contractor shall supply all necessary tools and Instruments etc. for installation, repair and maintenance in accordance to clause 3.2 "Tools and Instruments" of General Technical Specifications.

20.11 Special Tools

The Contractor shall list and supply all special tools. List of such tools including their make and detailed specification, shall be submitted for acceptance by the employer.

20.12 Deputation of Engineers for witness of Tests, Inspection & Training

The Employer's representatives shall be deputed for the following purposes.

Sl. No.	Description	Batch	No of Days	No. of Engineers and Technicians
1	Training at the plant and design office	1	5	2 Engineers 4 Technicians
2	Shop Inspection and Test	As and when required for inspection and test		

Note: This training is inclusive of scope of chapter 21.

The training of employer's personnel shall be as specified in clause 11.0 "Training of Employer's Personnel" of General Technical Specification.

20.13 Deviations from Specifications

All deviations from these specifications shall be separately listed in the requisite Performa of the bid document, in the absence of which, it will be presumed that the provisions of the specifications are fully complied with by the bidder. However, the deviations, which are better than the specifications shall be considered by the purchaser.

20.14 Completeness of Contract

Any fittings, accessories or apparatus required for successful commissioning though may not have been specifically mentioned in the specification but are usually necessary for the

completeness of the works shall be deemed to be included in the specification and shall be supplied by the bidder without any extra cost to the purchaser.

20.15 Appendix-1

Schedule of areas covered by HVWS system

Sl. No	Description	No of Transformers /OPU Tank	DV Qty /Each equipment
1	Generator Step up Transformer (63 MVA-1Ph)	12	1
2	Interconnecting Auto Transformer (67 MVA-1Ph)	3	1
3	Shut Reactor	1	1
4	Governor OPU tank	4	1
5	MIV OPU tank	4	1

Note: Deluge Valve quantities are tentative and may vary during detail engineering

20.16 Employer's Specifications (Hose Cabinet)

Sl. No.	Item	Unit	Specification
1	**General**		
1.1	Hose cabinet (refer sheet 3 for typical drawing)		Wall / Floor Mounted Hose Cabinets Suitable For 2 Nos. 63 mm DIA x 15 M Long Hoses And Accessories (Note 1,2)
1.2	Hose Cabinet With Hose Reel Size: _____ H x ____ W x ___ D	mm	Wall / floor mounted hose cabinets suitable for 2 nos.63 mm dia x 15 m long hoses, accessories and hose reel as per is 884 (note 1, 2)
1.3	Special Hose Cabinet	mm	SIZE: _____ H x ____ W x ___ D
1.4	Canopy Required (Note-3)		YES / NO
2	**Construction Features**		
2.1	Material Of Construction Of Cabinet Body		FRP / GI CRCA as per IS 277 & base metal conforming to IS 513
2.2	Thickness Of Body If Material Of Construction is GI CRCA / FRP	SWG / mm	16/18/20 SWG & grade of zinc coating 200 AS PER IS 277 / FRP-3mm
2.3	Thickness Of Glass Panel	mm	3
2.4	Hammer With Chain	SET	1 chrome plated
2.5	Lock With Duplicate Set Of Keys For Each Cabinet		YES
2.6	Mounting Clamps, Structural Support Legs Complete With Foundation Bolts, Nuts Etc.		YES / NO
2.7	Painting For GI CRCA MOC (Note 10)		
i)	External (spray paint)		1 Coat Of Red Oxide Primer 2 Coats Of Synthetic Enamel Finish Paint P.O. RED SHADE 538 AS PER IS 5
ii)	Internal (Spray Paint)		1 coat of red oxide primer 2 coats of synthetic enamel finish paint. Shade white
3	**Tests And Inspection**		
3.1	INSPECTION & TESTING		As per TCE.M4-185- 01 AND TCE.M4-185-74 OR TCE.M4-186-30

NOTES:

1. **Following accessories shall be made available inside the hose box after installation at site;**
2. **2 nos. 63 mm dia. x 15 m long hoses with coupling (All coupling should be Brass Made)**
3. **1 no. Branch pipe (Adjustable Branch, Stainless steel made)**
4. **1 no. Nozzle**

Sl. No.	Item	Unit	Specification

5. **1 no. Nozzle spanner**
6. **Floor mounted hose cabinets shall be provided with minimum 1 m high structural support legs.**
7. **Canopy (sloping top as indicated in drawing) is required for hose cabinets to be located outdoors.**
8. **The word "FIRE", in 150 mm letter size in red, shall be painted on the cabinet glass.**
9. **The cabinet shall be provided with clamps for holding branch pipe, nozzle and hose reel where applicable.**
10. **Provision to keep one key and one hammer in glass covered recess on the side of the cabinet shall be made.**
11. **The cabinet shall be supplied with a small container having a set of spare rubber rings packed in French chalk.**
12. **Making of pockets in the wall, grouting of bolts, finishing the wall as before, and mounting of cabinets on to the wall or the structural supports shall be in contractor's scope.**
13. **Colour shade scheme for FRP hose box shall be same as that mentioned for GI CRCA MOC – however the colour shall be UV resistant fade proof integral type suitable for external atmosphere.**
14. **The codes and standards mentioned in the various specifications and requirements specified in the enquiry document shall be latest as on the day of award of contract of the works unless otherwise specified. Contractor shall be responsible to inform to the Consultant / Owner in case of any revision / re-affirmation / amendment in the relevant codes and standards after the date of award of contract within 30 days of the issue of such revision / re-affirm/amendment of the code / standard. Consultant / Owner may approve use of the earlier code / standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed.**

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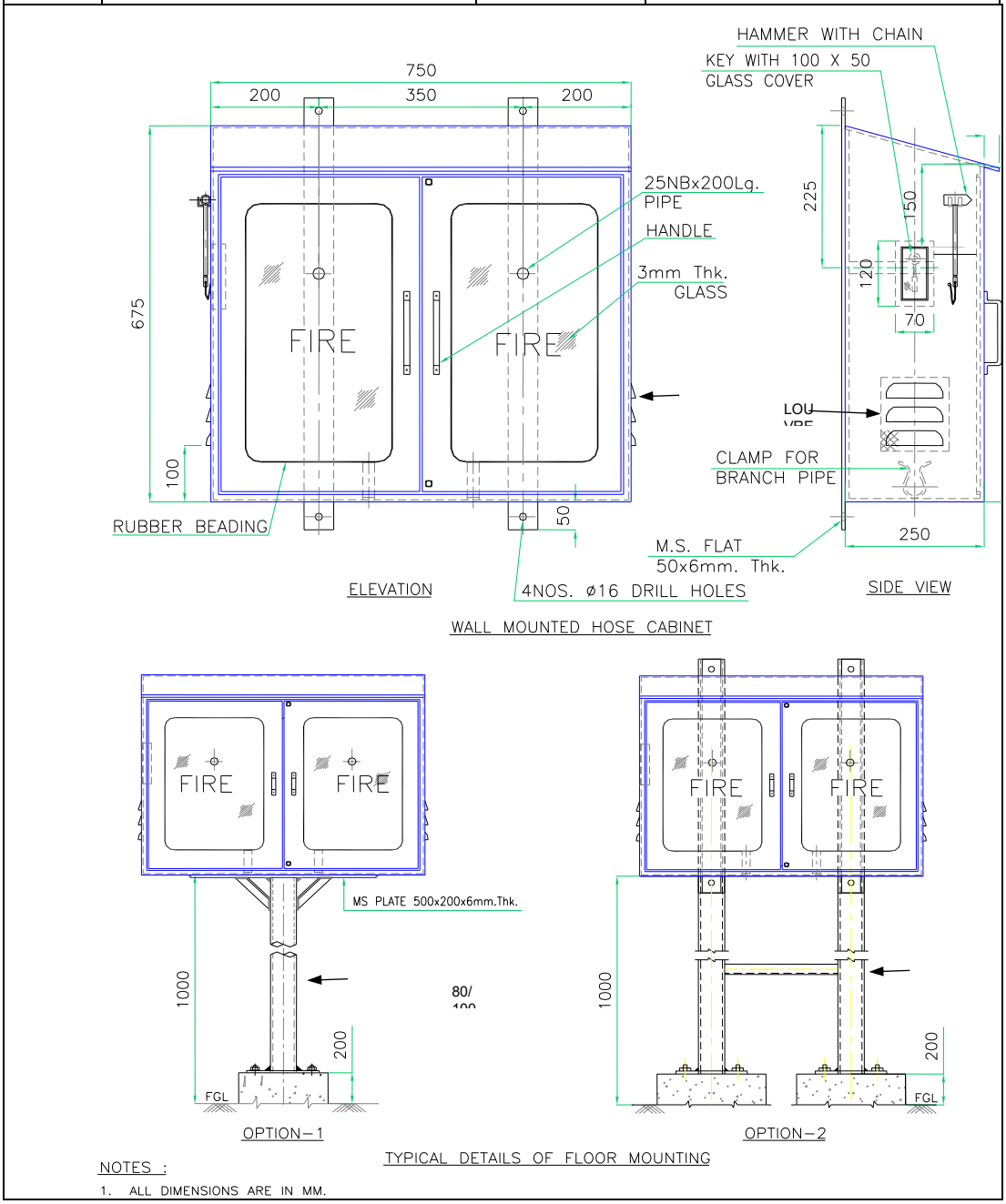
Sl. No.	Item	Unit	Specification



20.17 Employers Specification (Hose)

Sl. No.	Item	Unit	
1	**Standards**		
1.1	Hose		Type A OR AS PER IS 636 /IS 8423
1.2	Delivery Coupling		Instantaneous Spring Lock Type AS PER IS 903 (NOTE 1)
2	**Material of Construction**		
2.1	Hose		Rubber Lined Or Rubberised Fabric Lined, Woven Jacketted With Or Without Elastomeric Coating / Covering
2.2	Delivery Coupling		
i)	Copper Alloy		
a)	Sand Castings Conforming To		GR LTB2 OF IS 318 / GR HTB1 OF IS 304
b)	DIE Casting		GR 3 OF IS 292
c)	HOT Forgings		IS 291
d)	Gravity DIE Castings		IS 1264
ii)	Aluminium Alloy DIE Castings		Designations 4250,4450, 4600 OF IS 617
iii)	Stainless Steel Conforming To		GRADE 1 OR 4 OF IS 3444
3	**Dimensions**		
3.1	Diameter	mm	63
3.2	Length For Type Of Hydrant	mm	
i)	Internal / Fire Escape	m	7.5 /15 (NOTE 2)
ii)	External Hydrant	m	15 / 30
4	**Tests And Inspection**		
4.1	Hose Proof Pressure	$kg/cm^2(g)$	21.4 OR 35
4.2	Hose Burst. Pressure	$kg/cm^2(g)$	35.7 OR 50
4.3	Coupling Test Pressure	$kg/cm^2(g)$	21
4.4	Inspection & Testing		NFPA guidelines

NOTES:

1. **Each hose shall have one male half coupling at one end and one female half coupling at the other end. The couplings shall be joined with hose pipe as per the procedure detailed in tac fire protection manual. . (All Copper Couplings)**
2. **For TG hall, boiler house and mill bays of a power plant and basements 15 m long hoses shall be used.**
3. **The fire hose as well as coupling shall be ISI MARKED. (All firefighting hose system male & female required COPPER couplings for its superior corrosion resistance mechanical strength and durability under extreme condition and to ensure reliable, leak proof connection that can withstand high water pressure.)**
4. **The codes and standards mentioned in the various specifications and requirements specified in the enquiry document shall be latest as on**

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Sl. No.	Item	Unit	
	the day of award of contract of the works unless otherwise specified. Contractor shall be responsible to inform to the Consultant / Owner in case of any revision / re-affirmation / amendment in the relevant codes and standards after the date of award of contract within 30 days of the issue of such revision / re-affirm/amendment of the code / standard. Consultant / Owner may approve use of the earlier code / standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed.		

20.18 Employers Specification (Pipes and Nozzle)

Sl. No.	Item	Unit	
1	**General**		
1.1	Standard		IS 903
1.2	Type		Adjustable Branch Superior Quality Steel Made.
2	**Material Of Construction**		
2.1	Branch Pipe & Nozzle		
i)	Stainless Steel Conforming To		GRADE 1 OR 4 OF IS 3444
2.2	Washer		TYPE B OF IS 937
2.3	Nozzle Spanner		GR 35C4 OR 40C8 OF IS 1570 (PART 2 / SECTION 1) – With Plating Of Chromium Or Zinc
3	**Dimensions**		
3.1	Branch Pipe Inlet Size (Copper Made)	mm	63
3.2	Nozzle Bore	mm	20
4	**Spares And Maintenance Tools And Tackles**		
4.1	Essential Spares		
i)	Washer	Nos.	1
5	**Tests And Inspection**		
5.1	Test Pressure	$Kg/Cm^2(G)$	21
5.2	Inspection & Testing		

NOTES:

1. **The branch pipe with nozzle shall be isi marked. (brass made)**
2. **Branch pipe with nozzle shall be supplied along with spanner**

APPENDIX-1

SCHEDULE OF AREAS COVERED BY HVWS SYSTEM

Sl. No	Description	No of transformers/OPU Tank	DV Qty /Each equipment
1	Generator Step up Transformer (63 MVA-1Ph)	12	1
2	Interconnecting Auto Transformer (67 MVA-1Ph)	3	1
3	Shut Reactor	1	1
4	Governor OPU tank	4	1
5	MIV OPU tank	4	1

Note: deluge Valve quantities are tentative and may vary during detail engineering

APPENDIX-2

SCHEDULE ON TYPE OF FIRE DETECTION AND PROTECTION SYSTEMS PROVIDED FOR VARIOUS AREAS

Sl. No.	Area	Type of Fire Detection system	Type of Protection system
1	All Plant buildings, Powerhouse building all floors	Refer fire detection & alarm section	External & Internal Fire Hydrants CO2, Dry Chemical Powder (DCP) and water type portable fire extinguishers
2	Switchgear rooms & battery charger Room	Refer fire detection & alarm section	DCP type portable fire extinguishers, Trolley mounted CO2 Extinguisher
3	Battery rooms	Refer fire detection & alarm section	DCP/ CO2 type portable fire extinguishers
4	Cable galleries/Cable Vault /cable tunnel and wherever Cables are laid through Cable Trays	Refer fire detection & alarm section	Medium Velocity Water Spray (MVWS) system (Automatically operated) and Portable fire extinguishers
5	OM Staff room/ Library and Office Room	Refer fire detection & alarm section	Portable fire extinguishers
6	Auxiliary room	Refer fire detection & alarm section	Fire Hydrants, CO2 type portable fire extinguishers
7	Central Control room GIS control Room & any other control room	Refer fire detection & alarm section	Clean Agent Gas Extinguishing System and DCP/ CO2 type portable fire extinguishers.
8	Gas Insulated Switchyard (GIS)	Refer fire detection & alarm section	DCP/ CO2 type portable fire extinguishers inside the room
9	Transformers, Governor and MIV high pressure oil supply units.	Refer fire detection & alarm section	High Velocity Water Spray (HVWS) System. And DCP/ CO2 type portable fire extinguishers.
10	Machine Hall Floor and Service Bay	Refer fire detection & alarm section	Fire Hydrants, CO2 type portable fire extinguishers
11	Pothead yard	Refer fire detection & alarm section	Fire Hydrants, CO2 type portable fire extinguishers
12	Mechanical & Electrical workshop	Refer fire detection & alarm section	portable fire extinguishers, Fire Hydrants,
13	All pump houses in the plant	Refer fire detection & alarm section	portable fire extinguishers,
14	Lube oil area, DG houses	Refer fire detection & alarm section	portable fire extinguishers, Fire Hydrants (As needed),

CHAPTER 21: FIRE DETECTION AND ALARM SYSTEM

21.1 Scope of Work

This Specification covers the requirements of sizing, design, engineering, material selection, constructional features, manufacture, inspection and testing at the VENDOR'S or his SUB-VENDOR'S Works, delivery to Site including transit insurance, installation, testing & commissioning, training of employer's personals and performance testing of microprocessor based analogue addressable Intelligent fire detection and alarm system.

21.2 Codes and standards

i) The design, material, construction, manufacture, inspection, testing and performance of equipment shall comply with all currently applicable standards, codes of practice, regulations and safety codes in the locality where the equipment will be supplied & installed. Nothing in this specification shall be construed to relieve the CONTRACTOR of this responsibility.

ii) The codes and standards mentioned in the various specifications and requirements specified in the enquiry document shall be latest as on the day of award of contract of the works unless otherwise specified. Contractor shall be responsible to inform to the Consultant/ Owner in case of any revisions/reaffirm/amendment in the relevant codes and standards after the date of award of contract within 30 days of the issue of such revision/re-affirm/amendment of the code/ standard. Consultant/ Owner may approve use of the earlier code/ standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed.

iii) Other National Standards are acceptable if same are established to be equal to or superior to the listed ones. In all such cases however, copies of English translation of such National Standards shall be enclosed with the bid. Bids not complying with this requirement are liable to be rejected.

iv) The VENDOR shall ensure that instruments and gauges to be used for testing and inspection shall have valid calibration and the accuracy can be traced to National and International Standards as applicable.

21.3 Clearance and approvals

i) All detectors and sensors shall be approved by any of the following bodies as applicable.

a) Under writers' Laboratories (UL) - USA

b) Fire Officers Committee (FOC) – UK

c) FM Approval

d) Any other internationally recognised body acceptable to Purchaser / Consultant. Approval certificates shall be furnished with the bid.

ii) The Contractor shall be solely responsible for obtaining the required approval and clearance for the different components and systems of the fire detection and alarm system from the following authorities as applicable.

a) Fire officer/ Factory Inspector

b) Dept. of Atomic Energy (DAE) Certification of safety from radioactivity.

c) Central Building Research Institute (CBRL), Roorkee

d) Central Mining Research Station (CMRS), Dhanbad.

e) Local Fire Authority.

f) National Fire Protection Association, (NFPA)

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e) LPCB/VDS

21.4 General requirements

The design, construction and operational features of all types of detectors shall be in accordance with relevant standards as listed in Data Sheet – A2 of this specification.

21.5 Number, layout requirements and grouping of detectors

i) The number of fire detectors to be installed is governed by the total area to be protected, type of building construction (if indoors), air movement, air velocity, ceiling obstructions, value concentration of equipment in the area covered and the sensitivity required. Under ideal conditions of smooth ceiling and average room size, one detector is recommended to protect the area as specified in clause 4.4 (a) and (b). If ceiling construction or ducts / beams, etc., on the ceiling present obstruction to the spreading of heat / smoke on the ceiling, each area so divided by the duct / beam shall be provided with at least one separate detector.

ii) The number of detectors, spacing and their locations shall comply with relevant national/ international standards. The actual quantity of detectors required, taking into consideration the obstruction due to the depth of roof beams, etc., so as to obtain complete coverage, shall be worked out by the Contractor based on the final drawings of the various buildings during detailed engineering.

iii) The individual detectors shall be wired on a common connecting line. The number and exact location of detectors to be installed in the various areas will be finalised during detailed engineering stage by the fire alarm vendor.

iv) The fire alarm panel shall continuously monitor the status of the fire detectors and the connecting lines.

v) Following are some of the criteria to determine layout of the fire detectors:

a) All the fire detectors shall be of Multi sensor type for all control rooms, switchgear rooms, cable gallery, office rooms, toilets, closets etc. Rate of rise of temperature heat detectors with fixed temperature element setting shall be provided in Battery rooms, AHU/Air washer rooms etc.

b) For hazardous areas such as hydrogen generation plant or Hydrogen cylinder storeroom, DG house, Addressable intrinsically safe rate of rise of temperature detector with fixed temperature element and manual call points shall be provided.

c) As a matter of principle, detectors must always be installed at the highest point of the ceiling and minimum coverage indicated by the supplier shall be considered.

d) The number of detectors and their location should be so selected that complete coverage is obtained. The coverage of individual detectors should overlap, and no blind zone should be left.

e) Areas above false ceiling and below false flooring shall be considered as separate zones. For detectors mounted above false ceiling a separate response indicator shall be provided on the visible surface of the false ceiling close to the position of the corresponding detector. For detectors below false flooring a separate wall mounted response indicator box shall be provided. In such a case the response indicators shall be labelled to represent each detector. For each detector, Bidder shall provide inbuilt fault isolator with Response Indicator; however separate fault isolator module is also acceptable.

f) The rate of rise of temperature detectors shall also have fixed temperature setting.

g) The location of detectors shall be co-ordinated with other services like air-conditioning, light fittings, cable trays and raceways, false ceiling cut out or false ceiling tile arrangement. etc.

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h) Linear heat sensing cable (LHS cable) shall be of Digital type. The number and layout of LHS cables in cable galleries shall be decided based on tray width and number of tiers as per TAC guidelines. All necessary support structures shall be included in Contractor's Scope.

vi) In addition to fire detectors, manual call points of push type shall be provided at all locations, especially at the entrance to the battery / battery charger room, switchgear rooms, Power house areas cable gallery, transformer yard, etc., to actuate fire alarm system through remote manual intervention. Sequence of alarm and actuation scheme for manual call points shall be same as that for automatic fire detectors. The manual call points shall be of the wall mounting or pedestal mounting type. Manual call points shall be so located that no person need travel more than 30m from any point within the premises in order to raise an alarm.

21.6 Detector system for the different plant areas

i) The type of automatic fire detectors for the various plant areas are as follows:

Sl. No.	Plant Area	Type of Detection System
1	All Plant buildings, Power house building all floors	Addressable multi sensor detectors, photo electric detector, Addressable manual call points strategically located
2	Switchgear rooms & battery charger room,	Addressable multi sensor detectors and manual call points
3	Battery rooms	Addressable Rate of rise of temperature detector with fixed temperature element and manual call points
4	Cable galleries/Cable Vault /cable tunnel and wherever Cables are laid through Cable Trays.	Digital LHS cable, Addressable multi sensor detectors and manual call points
5	OM Staff room/ Library and Office Room	Addressable multi sensor detectors and manual call points
6	Auxiliary room	Addressable multi sensor detectors and manual call points
7	Central Control room, GIS control Room & any other control room	Addressable multi sensor detectors and manual call points, Response indicators
8	Khorlochhu Control room	Addressable multi sensor detectors and manual call points, Response indicators
9	Gas Insulated Switchyard (GIS) building	Beam detectors & manual call points.
10	Transformers, Governor and MIV high pressure oil supply units.	QBD (Quartzoid bulb detector), photo electric detector, manual call point
11	Machine Hall Floor and Service Bay	Beam detectors & manual call points.
12	Pothead yard	Smoke detectors, Temperature sensing bulb, manual pull station
13	Mechanical & Electrical workshop	Heat smoke detectors, manual call points
14	All pump houses in the plant	Addressable manual call points strategically located
15	Lube oil area, DG houses	Addressable intrinsically safe rate of rise of temperature detector with fixed temperature element and manual call points

i) For initial quantity estimation, the coverage of smoke / heat detectors shall be generally as follows:

a) 35 to 40 sq.m per detector for general application.

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b) 20 to 25 sq.m per detector for main control room, electronic cubicle room, computer room, etc., in view of high value concentration.

The exact requirement shall be calculated based on relevant standard.

21.7 Microprocessor Based Analogue Addressable Intelligent Fire Detection & Alarm System

i) The automatic fire detectors shall be of intelligent analogue addressable type having the following features:

Individual addressing capability at the fire alarm panel to facilitate precise pointing of fire location / detector activated.

a) Discrimination between a false fire and real fire condition.

b) Detection and automatic calibration / setting of over / under sensitive detector by decreasing or increasing their sensitivity levels.

c) Pre-alarm in case of detector or a section of detectors requiring maintenance.

d) All types of addressable detectors / interface units shall be compatible with the fire alarm panel.

e) Each loop shall have minimum 20% spare capacity for addition of detectors/devices.

ii) For expansion of existing facilities which are not addressable, the same shall be connected to Analogue interface module for integration with new Addressable system. All types of detectors offered shall have in-built electronic circuit for addressing capability for individual address on the fire alarm panel and shall have in-built short circuit isolating element.

iii) All types of detectors shall be suitable for connection in any particular loop / circuit with any other type of detector. In case of non-addressable type of detector or group of such detectors shall also be suitable for connection in the same loop / circuit by providing suitable addressable interface units.

iv) It shall initiate tripping of AHU for A/C system, air washer fans in ventilation system, package air-conditioners, Conveyor motors, closing of fire dampers, as required for the project etc. The system shall initiate operation of extinguishing systems such as deluge system.

v) 415V, 3ph, 3 wire 50HZ supply shall be provided for all Fire alarm panels (Main FAP / Sub FAP's / Repeater panel). Any other supply required shall be derived by bidder. All Fire alarm panels and repeater panel shall be provided with SMF Lead acid battery, the backup time of which shall be as per requirements of relevant standard (SMF Lead acid batteries shall be provided with minimum backup time of 48 hours for full load from the instant of charger / AC supply failure after which sufficient capacity would still be available for 30 minutes during alarm condition).

vi) The detectors shall be suitable for testing from the fire alarm panel without operating any detector & fire fighting system.

vii) Areas where two types of detectors are provided such as multi-sensor and linear heat sensor cables in cable galleries both the type of detectors shall be suitably cross zoned such that fire is detected only when both types of detectors located in that area operate which subsequently will operate the fire protection system. However, operation of any one of this type of detectors shall give an alarm.

viii) Each detector shall have an integral microprocessor capable of making alarm decisions based on fire parameter information stored in the detector head.

ix) The intelligent device and the loop card of FACP shall provide increased reliability and inherent survivability through intelligent standalone operation. The device shall

automatically change to standalone conventional device operation in the event of a communications failure with the loop controller.

x) In the standalone detector mode, the intelligent detector shall continue to operate using sensitivity and environmental compensation information stored in its microprocessor at the time of communications failure. The loop card shall monitor the loop and activate a loop alarm if any detector reaches its alarm sensitivity threshold.

xi) Each Intelligent device shall be capable of automatic electronic addressing and/or custom addressing without the use of DIP or rotary switches.

xii) Loop Power supply to the detectors shall be preferably 24 V DC until and unless it is technical necessity to have different voltage levels. In case the operating voltage of fire alarm components is greater than 24V DC, all detector junction boxes, manual call points and cable marshalling boxes shall be connected to the plant earthing grid through suitable earthing conductor at the nearest point available.

xiii) Each detector shall be provided with an indicating lamp glowing steadily to indicate that it has operated which shall otherwise flash intermittently to indicate the healthy condition of the detector and sensing circuits.

xiv) The smoke detectors shall continually monitor any changes in sensitivity due to the environmental effects of dirt, smoke, temperature, etc. This information shall be stored in the processor and transferred to the loop controller.

xv) The intelligent Analogue detectors shall be suitable for mounting on any intelligent detector mounting base. Common standard mounting bases shall be considered for all detectors.

21.8 Linear heat detection system (lhs)

i) Linear heat sensing cable (LHS cable) shall be of Digital type.

ii) The number and layout of LHS cables in cable galleries shall be decided based on tray width and number of tiers as per TAC guidelines.

iii) Necessary monitor modules shall be provided to connect this cable zone wise to addressable fire alarm control panel to indicate location and fire fault condition. The module box linked with DVLCP shall consist of monitor module, control module for indication and control.

iv) Laying of LHS cables shall be as per TAC guidelines.

21.9 Intelligent addressable monitor module

The module shall be suitable for connecting initiating type devices such as pressure switches, flow switches, level switches, and potential free contacts in the addressable loop. It shall be able to report its unique address to the panel to pin point the exact alarm location. An integral LED will be built in with the monitor module to indicate the status. It will be housed in a metallic/high plastic enclosure and suitable for indoor/outdoor location.

21.10 Intelligent addressable control module

The addressable control modules are provided for interlocking and controlling of the external appliances or equipment during fire. Some of the interlocking devices are: - shutting down of air conditioning and ventilation system, activating the operation of fire fighting equipment, operation of solenoid valve.

21.11 Manual call points

i) Push type Manual call points with all supporting structures shall be provided and shall be as per the guidelines listed in relevant national/ international codes/ standards.

ii) All types of manual call points (Indoor, outdoor and MCP with flame proof enclosure) shall be addressable. MCPs located in outdoor area shall be suitable for outdoor

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application with weather proof enclosure. MCPs located in hazardous area shall have Flame proof enclosures.

21.12 Microprocessor based fire alarm panel.

i) Microprocessor based fire alarm panel shall comprise of the redundant processor, various functional modules, adequate number of loop modules for detector loops, display devices, output modules for alarm control & interlocks, communication modules for interfacing etc., as required by the system to incorporate all the features called for in the specification. The control system shall be analogue type.

ii) One Main fire alarm panel shall be located in central control room. Repeater panels shall be considered as required. All these fire alarm panels shall be of microprocessor-based panels. Fire alarm panels shall be interconnected with redundant MODBUS TCP/IP links/fibre optic link/standard industry protocol as required. All Fire alarm panels shall be provided with integral HMI.

iii) Operating cum engineering station shall be provided at main control room for the main fire alarm panel. 32" OLED Monitor with key board, CPU and One A4 colour laser printer shall be provided by the Contractor.

iv) The microprocessor-based fire alarm panel shall incorporate the following features.

a) Continuous supervision of the detector connecting lines, individual detector performance / operation and disconnection / removal of detectors. The system shall automatically reset on clearance of a fault.

b) Discrimination between a real fire and false fire conditions by incorporating signal verification and other features.

c) Individual detector addressing capability.

d) Detection of over / under sensitive detectors and automatic calibration by increasing or decreasing their sensitivity levels based on environmental conditions like air movement, fumes, humidity, etc..

e) Pre-alarm in case of any detector / detectors requiring maintenance.

f) Facility shall be provided such that for alteration or access to the stored program the relevant codes are to be entered. The system should be protected against interference by unauthorised personnel.

g) Compatibility with all detector / devices connected to the fire alarm panel.

h) Logging of alarm, time and action text on printers.

i) Programmed activation of various interlocks with fire protection system and other associated system such as ventilation and air conditioning, etc.

j) Programmed activation of sequence of events to be carried out in case of fire in any particular protective area of the plant including activation of fire alarm sounders or evacuation alert signal.

k) System incorporating necessary features for hooking up with plant intrasite communication system, if specified.

l) It shall be possible to create coverage areas or logical groups in fire alarm panel. Each coverage areas/groups may contain a number of devices and each of these groups shall be individually addressable.

m) Ground fault detection facility

n) Field programmable & configuration facility

v) The design of the fire alarm panel shall be such as to incorporate the following features.

a) The circuits shall be arranged such that a fault in the detector or an open circuit in the connecting line does not affect the operation / performance of other detectors connected in that line and does not prevent receipt of fire alarm signals on the fire alarm panel from other detectors. In case of short circuit in the connecting lines, each detector shall be provided with short circuit isolating element.

b) Alarm verification features to reduce unwanted alarms wherein smoke detectors report alarm conditions for a minimum period of time, or confirm alarm conditions within a given time period after being reset, in order to be accepted as a valid alarm initiation signal.

c) The minimum no. of detectors or devices in a circuit loop shall be 99. The Bidder shall clearly indicate the maximum no. of detectors that can be connected in a circuit without affecting the performance / operation of the system.

d) The fire alarm panel shall have adequate number of detector circuit / loops so as to cover all the areas to be protected. Provision shall also be made in fire alarm panel to add additional detector loop modules for further expansion.

e) The fire alarm panel and field devices shall be suitable for Class A wiring as per relevant standards to meet all the requirements specified for the system.

f) The fire alarm panel shall automatically and periodically (at least once in 24 hrs) compare each sensor's operating characteristics with set sensitivity and recalibrate the dual alarm limits, if necessary.

g) The fire alarm panel shall have adequate potential free contacts for hooking up with HVAC feeders for automatic shutdown of AHU, PAC units in case fire is detected.

21.13 Central processing unit (cpu)

i) Central processing unit (housed in the fire alarm panel) utilising the microprocessor shall form the central monitoring unit for all the functions of the fire alarm system. Processor shall be of redundant processor.

ii) CPU shall have provision for communicating / interfacing with various components of the fire alarm system viz., HMI / Display unit FAP / LED monitor, printer, etc.

iii) The system software shall be specifically designed for fire detection and alarm system application which includes alarm processing, control status monitoring and various other functions to meet all the requirements of the system specified.

iv) The capacity of the processor shall be adequately designed to include all input / output signals and various functional requirements of the system.

v) The processor offered shall be 32 bit processor.

vi) The processor shall be designed to meet the following requirements:

a) Updating of analogue parameters display on Display unit / HMI / LED monitor shall be in less than 1 second.

b) In case of graphic display, time for display-on-Display unit / HMI / LED monitor screen on operator's request shall be less than 3 seconds.

21.14 OLED monitor with keyboard.

OLED monitor with processing unit and keyboard (PC) shall be provided in addition to the fire alarm panels. The OLED Monitor shall be located in the main control room.

i) The OLED monitor shall have the following features:

a) Colour monitor with graphic display facility.

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b) Data retrieval.

c) Alarm annunciation, accept and reset facility.

d) Display of individual detector status sensitivity and setting of detector sensitivity.

e) Commands and programming for performing various functions.

f) The graphic display shall cover all the areas of the plant and shall indicate the area / zone on fire by flashing. Upon selecting that area / zone, details of which detector / MCP has picked up shall be displayed. Any other features necessary for proper functioning of the system.

i) The OLED screen size shall be minimum 32 inches.

ii) The software used shall be provided with brief user's guide menu to enable the operator for proper use of various menu functions.

iii) Access to various programs and operation shall be through password to restrict the use to authorised personnel.

iv) The OLED shall be suitable for 240 V, 1 PH AC Power Supply.

21.15 Printer

i) Colour printer shall provide all outputs of status, alarms, events, acknowledgement, reset, commands, selection, etc., with time and date records.

ii) The printer format shall be with 80 columns and 96 characters. The printing speed shall be 58 lines per minute.

iii) Alarms shall be highlighted differently than other messages, including type, location, time, date, address of alarm point, etc. Multiple alarms shall be recorded in chronological order. If an alarm is received during the preparation of the reports, the printer shall interrupt the report to record the alarm received and resume automatically on receipt of alarm.

iv) All changes to system programming shall be recorded automatically.

v) Communication with CPU shall be monitored, and faults displayed on the LED.

21.16 Repeater panels

i) Repeater panel shall repeat all the group annunciation /alarms that appear in the Fire alarm panels. Repeater panels shall be considered as per requirement.

ii) Each repeater panel shall have a hooter, alarm, accept, reset and lamp test push button and lamps / LEDs for visual indication of fire and for auxiliary supply healthy.

iii) The repeater panel shall be provided with a dedicated battery.

21.17 Hooter with strobe

i) The electronic hooter being located at vital places have minimum audible level of 85 dBA above normal noise level of the working area. The hooter will have minimum two tone facility. Also, it shall be ensured that the entire area receives consistent illumination from the strobe flash.

21.18 Fire sirens.

i) Fire Siren shall have an identical wave tone. The same shall be activated from Main Fire Alarm Panel. The siren shall be capable of being heard distinctly throughout the plant area and shall comprise twin sounders.

ii) The siren shall be suitable for installation outdoors and shall be complete with rain shades and all other mounting accessories.

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iii) The sirens shall be motor operated type with AC motors of three phase design. The starters required for switching the sirens ON / OFF shall be supplied with them.

21.19 Auto dialler

The panel shall also have an auto-dialler for indicating fire alarms to the Fire Brigade & other agencies. It is an automatic device that can automatically dial telephone numbers to communicate between any two points in the telephone, mobile phone networks. Once the call has been established the auto dialler will announce verbal messages to the called party. Each auto Dialler for FDA system shall have at least four (4) numbers to dial.

21.20 Cables

21.20.1 Cables required for complete fire alarm system for interconnecting fire alarm panels, detectors, manual call points, other field devices, repeater panel, etc., shall be 1100V grade, multicore, annealed, high conductivity stranded copper conductor, extruded PVC/XLPE insulated, laid up inner sheathed, galvanised steel strip / wire armoured, outer FRLS extruded PVC sheathed cable as per relevant standards.

21.20.2 The Contractor shall supply and install all cables required for looping between detectors and manual call points and wiring out of connections to a marshalling / junction box in each zone as required.

21.20.3 The following cables shall also be supplied and installed by the bidder:

For microprocessor based Intelligent Analogue addressable system.

i) Between fire alarm panel and system PC (if kept at different location), Repeater panel, auto dialler.

ii) Between fire alarm panel / control interfaces and equipment associated with the fire protection system for control and interlocking.

iii) Between fire alarm panel, MCC and siren.

21.20.4 For indoor areas cables shall run along and clamped to structures, wall / ceilings or run in cable trays / racks provided by PURCHASER, wherever available. Wherever required cables shall run in rigid galvanised steel conduits to be supplied and installed by the CONTRACTOR.

21.20.5 Outer sheath for FRLS cables shall meet the following test requirements related to flame retardance, low smoke emission, low acid and toxic gas emission. The Bidders shall have proper test apparatus to conduct all the relevant tests as per the applicable Standards mentioned herein.

21.21 Test for Flame Retardance.

i) Oxygen index

The critical oxygen index value shall be minimum 29 when tested at 27+2ºC as per relevant standard and the temperature index value shall be minimum 250ºC at oxygen index of 21 when tested as per relevant standard.

ii) Flammability

a) Cables shall pass test under fire conditions as per relevant standard.

b) Cables shall also pass tests as per relevant standard.

c) Fire survival cables in addition to tests (i) and (ii) above shall pass tests as per relevant standard.

iii) Test for smoke generation.

The cables shall satisfy the tests conducted to evaluate the percentage obscuration by smoke in an optical system placed in the path of the smoke. The maximum smoke

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density rating shall not be more than 60% when tested as per relevant standard.

iv) Tests for acid gas generation

The hydrochloric acid generation when tested as per relevant standard shall be less than 20% by weight.

v) Tests for resistance to ultraviolet radiation

This test shall be carried out as per relevant standard. The retention values of tensile strength and ultimate elongation after the tests shall be minimum 60% of tensile strength and ultimate elongation before test.

vi) Tests for water absorption

Outer sheathes shall be subjected to tests for water absorption as per relevant standard. When additional characteristics are required, the tests shall be as agreed to between PURCHASER and BIDDER.

21.22 Tests

The CONTRACTOR shall conduct all the type, routine and functional tests for $_{all}$ equipment supplied under this contract and for the system as installed. Tests shall be conducted as required by the relevant standards as well as by the PURCHASER/ENGINEER. Copies of all test certificates shall be furnished.

21.23 Accessories

Following accessories may be considered along with the main equipment-

i) Licensed software (FDA system software, operating system, GUI software.

ii) Power cable, control cable, optical fibre, network cable, special cable.

iii) Computer table, printer table and chairs.

iv) Network equipment and associated rack.

v) Cabling accessories like LIU, patch chord, pigtail, coupler, connectors and erection accessories like GI/HDPE conduits, saddles, nuts, earthing material and other consumables as required.

vi) Detector maintenance tool kit.

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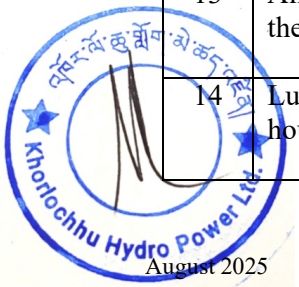
21.24 Appendix

Schedule on type of fire detection and protection systems provided for various areas

Sl. No.	Area	Type of Fire Detection system	Type of Protection system
1	All Plant buildings, Powerhouse building all floors	Refer fire detection & alarm section	External & Internal Fire Hydrants CO2, Dry Chemical Powder (DCP) and water type portable fire extinguishers
2	Switchgear rooms & battery charger Room	Refer fire detection & alarm section	DCP type portable fire extinguishers, Trolley mounted CO2 Extinguisher
3	Battery rooms	Refer fire detection & alarm section	DCP/ CO2 type portable fire extinguishers
4	Cable galleries/Cable Vault /cable tunnel and wherever Cables are laid through Cable Trays	Refer fire detection & alarm section	Medium Velocity Water Spray (MVWS) system (Automatically operated) and Portable fire extinguishers
5	OM Staff room/ Library and Office Room	Refer fire detection & alarm section	Portable fire extinguishers
6	Auxiliary room	Refer fire detection & alarm section	Fire Hydrants, CO2 type portable fire extinguishers
7	Central Control room GIS control Room & any other control room	Refer fire detection & alarm section	Clean Agent Gas Extinguishing System and DCP/ CO2 type portable fire extinguishers.
8	Gas Insulated Switchyard (GIS)	Refer fire detection & alarm section	DCP/ CO2 type portable fire extinguishers inside the room
9	Transformers, Governor and MIV high pressure oil supply units.	Refer fire detection & alarm section	High Velocity Water Spray (HVWS) System. And DCP/ CO2 type portable fire extinguishers.
10	Machine Hall Floor and Service Bay	Refer fire detection & alarm section	Fire Hydrants, CO2 type portable fire extinguishers
11	Pothead yard	Refer fire detection & alarm section	Fire Hydrants, CO2 type portable fire extinguishers
12	Mechanical & Electrical workshop	Refer fire detection & alarm section	portable fire extinguishers, Fire Hydrants,
13	All pump houses in the plant	Refer fire detection & alarm section	portable fire extinguishers,
14	Lube oil area, DG houses	Refer fire detection & alarm section	portable fire extinguishers, Fire Hydrants (As needed),



21.25 Employer's Specifications

Sl. No.	Description	Units	Specification Requirements
1	**Automatic Fire Detection system**		
1.1	General		
i)	Resettability of detectors		Remote resettable
ii)	Interchangeability of detectors		To be provided
iii)	Response Indicator		Lights up steadily to indicate healthy condition. Flashes intermittently under alarm condition
iv)	Test facility		To be provided
1.2	Addressable Multi sensor detector	Req / Not req	To be considered as per building & Plant GA
1.3	Addressable Rate of rise of temperature detector with fixed temperature element.	Req / Not req	
1.4	Addressable IR spark / ember detector	Req / Not req	
1.5	Beam detectors	Req / Not req	
1.6	Digital Linear Heat sensing cables	Req / Not req	
1.7	Tank mounted probe type Heat detectors	Req / Not req	
1.8	Flame detectors	Req / Not req	
1.9	Electronic Hooters	Req / Not req	
1.10	Addressable Interface Unit	Req / Not req	
1.11	Addressable Manual call points	Req / Not req	
i)	Type		Push type
ii)	Degree of protection for enclosure		Indoor: IP 54 Outdoor: IP 55
2.0	**Fire Alarm Panels**		
2.1	Power supply		
i)	Fire alarm panels		230V, 1ph, 50HZ UPS supply
2.2	Degree of protection for Fire alarm panels		- IP52 for indoor protected areas IP54 for indoor plant areas - IP55 for outdoor areas
2.3	Paint shade of panels		RAL 7035
2.4	Integral battery backup provided. (Battery backup time as per IS 2189)		Yes
2.4	Type of battery		Ni-Cd / SMF Lead Acid
2.5	Whether Redundant processor considered for FAP		Yes
2.6	Integral HMI / Display unit considered on FAP		Yes

Sl. No.	Description	Units	Specification Requirements
2.7	Operating & Engineering station considered for Main Fire alarm panel which includes.		Yes
i)	OLED monitor		
ii)	CPU		
iii)	Printer		
iv)	UPS for operating workstation		
2.8	Provision for signal to siren control panel in case of fire	Yes / No.	Yes
3	**Fire Sirens**		
3.1	Type of tone		Dual tone
3.2	Range of siren	kms	
3.3	Location of Siren		
3.4	Power supply		
3.5	Whether mounting accessories & starters for siren provided	Yes / No.	Yes
3.6	415 V, 3 phase, Motor		Yes
4	**Cables**		
4.1	Voltage grade		1.1 kV control cables
4.2	Size and No. of cores		2CX1.5 sq mm for looping cables 2CX2.5 sq mm for power cables
4.3	Type of cables		Extruded FRLS (Fire retardant low smoke) PVC outer sheathed
5	**Earthing**		
5.1	Fire detectors / Marshalling boxes	Sq.mm	During detailed engineering
5.2	Fire alarm panels/Repeater panels/Fire siren	Sq.mm	During detailed engineering
6	**Additional system requirements**		
6.1	Interfacing with plant Intrasite communication system	Yes/No	Yes
6.2	Auto Dialler system	Yes/No	Yes
6.3	Interfacing with DVLCP, HVAC system	Yes/No	Yes
6.4	Interfacing with Generator protection panel, transformer protection panel for indication	Yes/No	Yes, as required.

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21.26 Applicable Standards

Sl No.	Title	Standards
1	Code of practice for selection, installation & maintenance of automatic fire alarm & detection system.	IS-2189 /BS-5839 PART-1/ANSI-NFPA-72/ FOC RULES
2	Code of practice for fire safety of buildings (General) : Electrical installation.	IS-1646
3	Code of practice for fire safety of industrial buildings: Electrical Generating & Distributing stations	IS-3034
4	Components of automatic fire detection system: Introduction	BS-5445 PART-1
5	Specification for manual call points	BS-5839 PART-2/ANSI-UL38
6	Smoke detectors for use in automatic fire alarm system	IS-11360/BS-5445 PART-7/ANSI-UL268
7	Smoke detectors for duct application	ANSI-UL268A
8	Single & multiple station smoke detectors	ANSI-UL217
9	Heat sensitive fire detectors for use in automatic fire alarm system	IS-2175/BS-5445 PART-5
10	Specification for high temperature heat detectors	BS-5445 PART-8
11	Methods of test of sensitivity to fire	BS-5445 PART-9
12	Auxiliary protective signaling system for fire alarm services	ANSI-NFPA-72
13	Automatic fire alarm system in buildings: Control & indicating equipment	BS-3116 PART-4
14	Basic environmental testing procedures for electronic and electrical items.	IS-9000
15	Cables	IS-1554 PART-1/ IS-7098 PART-I
16	Degree of protection provided by enclosures for low voltage switchgear and control gear.	IS-13947
17	Flame proof enclosures of electrical apparatus	IS-2148
18	National Electric Code	ARTICLE 760
19	National Building Code of India	NBC 2016
20	Rules for fire alarm system	TAC
21	Standard test method for density of smoke from the burning or decomposition of plastics	ASTM-D-2843
22	Artificial weathering or exposure to filtered xenonarc radiation	DIN EN ISO 4892-2

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21.27 Mandatory Spares

	Fire Detection & Alarm system	
Sl. No.	**Item**	**Quantity**
1	Manual call points	3 Nos of Each Type
2	Multi sensor detector	3 Nos of Each Type
3	Beam detector	3 Nos of Each Type
4	Digital LHS cable	10% of total Qty
5	Addressable Rate of rise of temperature detector	3 Nos of Each Type
6	Addressable Interface Unit	3 Nos of Each Type
7	Electronic Hooters	3 Nos of Each Type
8	QBD (Quartzoid bulb detector)	10 Nos of Each Type
9	Cables	10% of total Qty

CHAPTER 22: MV SWITCHGEAR

22.1 Scope of Work

This Specification covers the requirements of sizing, design, engineering, material selection, constructional features, manufacture, inspection and testing at the VENDOR'S or his SUB-VENDOR'S Works, delivery to Site including transit insurance, installation, testing & commissioning and performance testing of Medium Voltage Metal Enclosed Switchgear.

22.2 Codes and Standards

The design, material, construction, manufacture, inspection, testing and performance of equipment shall comply with all currently applicable standards, codes of practice, regulations and safety codes in the locality where the equipment will be supplied & installed. Nothing in this specification shall be construed to relieve the CONTRACTOR of this responsibility.

The codes and standards mentioned in the various specifications and requirements specified in the enquiry document shall be latest as on the day of award of contract of the works unless otherwise specified. Contractor shall be responsible to inform to the Consultant/ Owner in case of any revisions/re-affirm/amendment in the relevant codes and standards after the date of award of contract within 30 days of the issue of such revision/re-affirm/amendment of the code/ standard. Consultant/ Owner may approve use of the earlier code/ standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed

In case of conflict between the applicable standards and this specification, the more stringent of the two shall govern.

22.3 MV Switchgear Panel

The following list of switchgears are covered under is specification. Additional details refer data sheet A:

i) 11 kV Switchgears at Powerhouse

ii) 11 kV Switchgears at Pot headyard

iii) 33kV Switchgears at For BFV, Surge Shaft, Chuplangchhu Intake , Tailrace Outfall and Dam Area.

iv) Any other switchgear as per project requirement and also refer SLD.

The preliminary details such as continuous current rating of the bus bar, feeders, minimum protection relays, and meters, etc to be provided as shown in the Single line diagram. The Contractor shall review the rating of equipment required for the system offered, the protection relays and meters for effective protection and monitoring of the equipment being supplied and add additional relays/meters and suitable rated equipment as required.

The complete switchgear shall be procured from the same source to ensure interchangeability of components.

22.4 Constructional Features

The switchboard shall be indoor, floor mounted, metal clad, draw-out having separate metal enclosed compartments for

i) Circuit breakers

ii) Phase bus bars

iii) Instrument transformers.

iv) Power cable terminations

v) Control, metering & relaying devices.

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Adjacent cubicles (panels) shall have sheets on either side to ensure complete isolation. The bottom of each panel shall be covered by sheet steel and necessary glands plates. Switchgear shall be suitable for extension on both sides.

Total height of the switchgear panels shall not exceed 2600 mm. The height of switches, push buttons and other hand operated devices shall not exceed 1800 mm and shall note less than 700 mm.

The switchboard shall have passed internal arc testing (A FLR) for 1 second at the rated switchgear fault current. Pressure relief flaps and Gas duct shall be provided at the top of the switchboard with suitable exhaust arrangement to release hot over-pressurised gases in case of an internal fault to vent arc flash & hot gases away from operator (outside the building). The internal arc time could be 0.5 sec or 0.1 sec at switchgear rated fault current in case rapid fault clearance time initiated by detectors sensitive to light, pressure, or heat or by bus bar differential protection is provided.

Notes: (a) A stands for: Authorized (b) F stands for : Front (c) L stands for : Lateral (d) R stands for : Rear

Required number of high-speed trip relays, supervision relays, auxiliary relays, timers, contact multiplication relays, etc. shall be provided in the panels to meet the system requirements and to meet the system operation philosophy.

The circuit breaker shall be draw out type and it shall have test, service and isolated positions. In test position the circuit breaker shall be capable of being tested for operation without energizing power circuits.

The current transformers shall be mounted in the fixed portion of the switchgear. Adequate space shall be available for termination using heat shrinkable type cable termination in cable compartment.

Withdrawal of circuit breaker shall not be possible unless it is in open position and operation of circuit breaker shall not be possible unless it is fully in service position or is fully in test position and drawn-out position.

All non-current carrying metal work of the switchgear shall be effectively bonded to the earth bus. Hinged doors shall be earthed through flexible for each type of breaker.

Busbar and circuit earthing facility shall be provided either through earthing switches or separate earthing trucks. These earthing devices shall be suitably interlocked with the circuit breaker / disconnector to avoid accidental earthing of live parts.

Switchgear shall be supplied completely wired and inter panel wiring between cubicles of same switchgear shall be provided.

Breaker control switches shall be pistol-grip black and selector switches shall be oval or knob, black. Breaker control switches shall be 3 position spring returns to neutral, instrument selector switches shall be of maintained stay put type.

i) Push buttons provided shall be shrouded.

ii) Space heaters of adequate capacity shall be provided.

iii) Each switchgear panel shall be provided with 240Volts, 1 phase, 50Hz, 5amps, 3 pin receptacle with switch located in a convenient position.

Provision shall be made for receiving, distribution, isolating and fusing of auxiliary DC and AC supplies for controls, space heating, etc. Two numbers DC feeders shall be provided for switchgear with selector switch for selecting any one supply. DC supply supervision lamps with series resistors shall be included.

The rating of instrument transformers indicated in the one-line diagram is preliminary. However, the Bidder shall confirm adequacy of the same based on connected load, lead

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burdens, and changes during engineering stage, if any, and adequate margin at the time of handing over the plant.

i) VTs shall be housed in a separate sheet metal enclosure.

ii) The termination kit shall be heat shrinkable / cold shrinkable type.

iii) MV and LV switchgear - Should have proper LOTO arrangement.

iv) In MV switchgear Back doors should have adequate safety interlock system as well as the indication of live circuit to be provided.

v) Suitable fire detection system in the bus and cable compartment to be provided.

vi) Easy physical identification of bus coupler panel / tie-feeder panel shall be considered.

vii) Rack-IN/Rack-Out system for MV breaker shall be provided.

viii) Cable lugs for all power, control and instrumentation cable connections shall be supplied. The lugs shall be tinned copper/aluminium depending on cable conductor and of solderless crimping type. The cable glands shall be of double compression brass cable glands shall be supplied.

All breakers of identical ratings shall be interchangeable, suitable mechanical / electromechanical interlocks to ensure that earth switch is not closed / truck is not inserted with the bus live or cable side energised.

Rubber mats suitable for HV of receptive panels grade shall be provided at front and rear of switchgear.

22.5 Cubicle Components

Each circuit breaker cubicle shall be provided with the following minimum standard accessories in addition to suitably rated circuit breaker:

i) One control switch `Trip - Neutral - Close' spring return to neutral position.

ii) One control selector switch `Local - Remote’ stay put type.

iii) Indicating lamps –

a) ‘Red’ for breaker `ON' indication and trip coil supervision

b) ‘Green' for breaker `OFF' indication

c) ‘Blue' for breaker in 'Service' position

d) ‘Amber' for breaker in 'Test' position

e) 'White' for breaker closing spring 'Charged'

f) 'White' supervision lamp for lockout relays

iv) The indicating lamps shall be clustered LED type. They shall be bright and visible from any angle.

v) Mechanical trip push button to trip the breaker when control supply is lost. The push button shall be shrouded type. Mechanical close push button provided shall be accessible only after opening of the front door.

vi) One electrical anti-pumping relay.

vii) One double pole control supply switch and set of fuses

viii) One breaker operation counter

ix) Cubicle lamp, heater with thermostat and plug point

x) All the meters shall be digital type including Ammeter & Voltmeter. All digital meters shall indicate true RMS. Digital Multifunction meter shall display all electrical

parameters like (but not limited to) following metering features : Current, Voltage, Frequency, Energy (kWh), MD (kW/kVA), PF, kVAh, kVAr, kVARh, V THD, I THD, etc. Multi-function meters with communication facility for SCADA interconnection, etc.

xi) Composite type Numerical protective relays with communication facility for SCADA interconnection. Relays shall be in draw-out cases with built-in test facilities or plug in type with proper testing facilities. Numerical protective relays shall have conformal coating.

xii) The tripping relays shall be latch-in type with hand reset facility and shall preferably have operating time not exceeding 20 ms.

Switchgear working zone (i.e. mounting of all components required for operation and monitoring) shall be restricted within 750mm to 1800mm from floor level.

Provision shall be made for the extending the switchgear no of incomers and outgoing feeders at later stage.

22.6 Safety Interlocks & Features

Switchgear shall be provided with the following minimum interlocks:

Withdrawal or engagement of circuit breakers or disconnecting switch shall not be possible unless it is in the open position.

Operation of circuit breaker or disconnecting switch shall not be possible unless it is fully in service position, or in test position or in fully drawn-out position. The interlock shall prevent the closing of the circuit-breaker, switch or contactor in the service position unless any auxiliary circuits associated with the automatic opening of these devices are connected.

Operation of a disconnecting switch shall not be possible unless the associated circuit breaker is open.

Circuit breaker / disconnecting switch cubicles shall be provided with safety shutters operated automatically by the movement of the circuit breaker / disconnecting switch carriage to cover the exposed live parts when the breaker is withdrawn.

A draw-out breaker / disconnection switch of given rating shall be prevented from engaging with a stationery element of higher rating.

The Circuit breaker / disconnector carriage shall be earthed before the carriage reaches test position from fully withdrawn position. Further while racking out, earthing shall get disconnected only after test position. The earthing busbar & the contact shall be designed for full fault current with minimum contact resistance.

The closing and tripping circuits of each cubicle will be interlocked electrically with the PURCHASER'S equipment and the VENDOR shall arrange the necessary interlocks.

22.6.1 Cable Live Indicator Shall Be Provided on Each Feeder With Following Features:

i) Voltage present indication shall be self-powered and independent of aux. supply.

ii) Suitable for Aux. supply of 0-250V DC system (with centre tap grounding

iii) Provision shall be available for measurement of secondary voltages, which shall be used for phasing in measurements.

iv) Secondary voltages shall be minimum of 10V with respect to ground at service voltage of switchboard.

v) It shall have 2 relay output contacts for remote indication & interlocking.

vi) TEST mode to check the healthiness of indication & contacts.

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vii) Interlocking mechanism shall be provided between cable compartment and breaker to ensure:

viii) Back side panel can't be opened unless the breaker is OFF and isolated condition.

ix) Breaker shall not go in service unless the back-side cable box cover is closed and locked.

22.7 Painting

All switchgear panels shall be painted providing an aesthetically pleasing appearance, free from dents and uneven surfaces. Paint shade shall be RAL 7035.

22.8 Busbars

Material of main and tap off busbars shall be of electrical grade and be of Copper / Aluminium.

The sizing criteria for a Typical MV Switchboard shall be determined by the size of the transformer feeding the board. As a design Philosophy the Board continuous current shall be selected as (1.1) * (Full load current at rated voltage on the Transformer's secondary) at 50 °C ambient.

Busbars shall be rated to meet the service conditions and the rated continuous and short time current ratings. Maximum temperature of the main busbars and busbar connections, under operating conditions, when carrying rated normal current at rated frequency shall not exceed 90/105ºC for non-silver plated/silver plated joints/connections. Busbar temperature limits shall be adhered to without forced cooling method. For tap-off busbars, the current rating shall be at least equal to corresponding breaker(s) rating.

All busbar joints and bus tap joints shall preferably be silver faced.

Unless supported by impulse voltage withstand test results, phase to phase and phase to earth clearances in air for the busbars and live parts shall not be less than those specified.

Busbars shall be adequately supported on insulators, to withstand dynamic stresses due to short circuit current specified.

Main busbars shall be located in air insulated enclosures and segregated from all other compartments of the cubicle. Direct access or accidental contact with busbars and primary connections shall not be possible.

The busbars shall be with flame retardant heat shrinkable sleeve. All joints shall be provided with removable shrouds.

The busbar sleeves and shrouds shall be suitable for continuous operating temperature of 5°C higher than the maximum permissible operating temperature of busbars / joints.

The sleeving material shall not crack, peel or loosen on the busbars when subjected to thermal cycling during service and shall be of such quality as not to require replacement for life of switchgear.

22.9 Circuit Breakers

Vacuum Circuit Breakers shall be offered. Breakers of identical ratings shall be fully interchangeable. Circuit Breaker with forced air-cooling for increasing its rating shall not be acceptable.

For circuit breakers to have interchangeable ability, the breaker rating shall be standard and limited to two types or current ratings.

Rack- in / Rack-out of circuit breakers shall be considered.

The vacuum breakers shall be complete with surge arrestors to provide protection to the equipment against switching surges. Location of the surge arrest or must be kept after CT and before cable/busduct outgoing terminals in all outgoing feeders, i.e., protection reach.

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Plug and socket arrangement when provided, shall have adequate number of pins to meet the requirements of control and interlocking scheme. The plug and socket arrangement shall be so designed that it shall be possible to insert the plug in the socket in one position only, thereby eliminating the possibility of faulty insertion and wiring. The plug, after insertion, shall be secured in position by spring clamps, which need considerable force to operate. The length of the plug chord will be such that the plug can be inserted into the socket only when the breaker is pushed into the test position. Suitable interlock will be provided to permit further pushing of the breaker only if the plug is inserted correctly into the socket. It shall not be possible to remove the plug when the breaker is in service position, and it shall be necessary to withdraw the plug from the socket before the breaker can be pulled out from the test position to fully withdrawn position.

Telescopic trolley or suitable arrangement shall be provided for maintenance of circuit breaker module in a cubicle for cassette type breakers. The trolley shall be such that the topmost breaker module can be withdrawn on the trolley and can be lowered for maintenance purpose. The telescopic trolley shall be such that all type, size and rating of breaker can be withdrawn / inserted.

22.9.1 Circuit Breaker Duty.

Circuit breakers shall be re-strike free and suitable for switching duty of transformer whose maximum capacity. Adequate provision shall be made on circuit breakers for motor switching to limit the over voltage to 2.2 p.u. rated peak line to earth voltage (1.0 microsecond. to crest).

22.9.2 Design of Outgoing Feeders:

The various outgoing feeders shall be feeders for motors, auxiliary transformers, tie feeders, and supply feeders.

While sizing the outgoing feeder, the rating shall be calculated based on the following as a minimum and as required:

22.9.3 Transformer feeder:

Transformer KVA/primary [Voltage* 1.732] *1.1 (at least) Tie feeder: As per system requirements lncomer feeders: generally, the same as the board rating Bus Couplers: Same as incomer Feeder rating.

Closing and Opening operation time difference shall be limited to 2 cycles (40 ms) to facilitate fast bus transfer operation.

22.9.4 The breakers controlling motors shall be provided with suitable devices to operate satisfactorily under the following conditions:

i) Direct-on-line starting of motor whose maximum capacity and starting time.

ii) The frequency of motor starting can be either one start from hot condition or two successive starts from cold condition or three equally spaced starts in an hour from hot condition.

iii) Suitable shunt resistors or surge arrestors, if necessary, shall be provided to restrict the voltage peaks during switching off motor, to 2.2 p.u. of rated peak line to earth voltage.

iv) Surge arrestor selected shall be suitable for non-effectively earthed system and rating shall be in such a way that the value of steep fronted switching over voltage generated the switchgear terminals shall be limited to the requirements of switchgear.

22.9.5 Circuit Breaker Operating Mechanism

Operating mechanism shall be non-pumping electrically and mechanically under every method of closing (except during manual closing of a breaker for maintenance). Electrical anti-pumping feature shall be provided.

Circuit breaker shall be power operated by a motor charged spring operated mechanism.

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Mechanism shall be such that failure of any auxiliary spring shall not prevent tripping and will not cause tripping or closing operation of the power operated closing devices. When the circuit breaker is already closed, failure of any auxiliary spring shall not cause damage to the circuit breaker or endanger the operator.

The closing release shall operate correctly at all values of voltage between 85% and 110% of the rated voltage. A shunt trip shall operate correctly under all operating conditions of the circuit breaker up to the rated breaking capacity of the circuit breaker and all values of supply voltage between 70% and 110% of rated voltage.

Spring charging motor shall be rated such that it requires only about 30sec. for fully charging the closing spring. Motors shall be rated for 220V / 110 V DC and shall operate satisfactorily at all values of voltage between 85% to 110% of rated voltage.

Mechanical indicators to indicate charged and discharged condition of spring shall be provided.

Alternate means must be provided to charge the closing springs manually when power supply to motor is not available.

22.9.6 Operating Mechanism Control

Operating mechanism shall normally be operated by remote electrical control panel when the breaker is in "Service" position. Electrical tripping shall be performed by shunt trip coils. Provision shall also be made for local electrical control when the breaker is in "Test" position by a control switch on the switchgear cubicle door. Also, "Local/Remote" selector switch lockable in "Local" position shall be provided on the cubicle door. `Red' and `Green' indicating lamps shall be provided on cubicle door to indicate breaker close and open positions. Breaker "Service" and "Test" positions shall be indicated by separate indicating lamps on the cubicle door, in case mechanical indication of "Service" and "Test" positions are not available on the cubicle door. Breaker trip indication (amber lamp) shall be provided on the breaker feeder. All the lamps shall be of clustered LED type.

22.10 Disconnector / Switch Disconnector / Fuse Unit

Disconnectors shall be of the 'off-load' type. If required on load Disconnectors (load break switches) may be provided and be complete with suitably sized HRC or expulsion type fuses up to 630A & 36kV.

In case of on load Disconnector the short time & peak withstand current rating of the Disconnector shall be same as that of the associated breakers. The on load Disconnector shall be capable of breaking capacitive current similar to its continuous rating & making capacitive current as per associated breaker making capacitive current rating.

Position indicating 'Red' and 'Green' lamps shall be provided on the Disconnector cubicles. In addition, contacts shall be wired upto terminal blocks for connecting lamps for remote indication of Disconnector position

Mechanical and electrical interlocks shall be provided where applicable to ensure that the Disconnectors cannot be operated unless the associated breakers are open.

Disconnectors shall be provided with suitably designed motor drive. Motor drive shall be complete with suitably rated starter including fused disconnects.

22.11 Instrument Transformers

The current transformers (CTs) and voltage transformers (VTs) shall conform to the requirements stipulated in relevant standards. It shall be the responsibility of the Contractor to choose the rating and parameters of the instrument transformers to ensure that the ratings/parameters are adequate for the relays and meters specified taking into consideration the lead resistance for the remote connected equipment. The parameters of the instrument transformers shown in the Single line diagrams shall be for guidance only compatible with the type of protections and metering provided.

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Most of the relays shall be of short-time rated for 70In or 100In with max secondary amps indicated for 1 sec. The vendor shall select the CT tap, ratio, burden etc based on continuous ratings, short time rating, setting range, sensitivity of protection involved.

The CTs and VTs shall be of cast resin type (with winding insulation of B) and shall be able to withstand the thermal and mechanical stress resulting from the rated short time withstand and peak withstand current of the switchgear. All CTs shall be window type.

CTs and VTs shall have polarity marks indelibly marked on each transformer and at the associated terminal block. Facility shall be provided for short circuiting and earthing the CT secondary at the terminal blocks.

VTs shall be of the single phase type and mounted on a draw out trolley. VTs shall be protected on their primary side by current limiting fuses and secondary side by MCBs. MCBs shall be suitably located to permit easy replacement while the switchgear is energized. MCB's shall be provided with auxiliary contacts. Precautions shall be made such that the primary fuses can be handled only in the de-energised position. Draw out contacts for Phase and Neutral terminals shall be identical.

Also shutters shall be provided to automatically seal off the high voltage spouts when voltage transformers are withdrawn.

One additional open delta winding with damper resistance shall be provided for all VTs.

Core balance CTs shall be such that the earth fault relay should be able to operate over its entire range

Feeders requiring remote metering and/or current monitoring shall be provided with current transducers with calibration for full-scale reading. Transducer shall be dual channel type. The transducers shall have 4–20mA dual output and accuracy class shall be less than 0.5%.

22.12 Wiring & Accessories

All wiring shall be carried out with 1100V grade, single core, FRLS-PVC, flexible multi stranded copper conductor wires and shall be vermin and rodent proof.

The internal wiring shall be with 1.5sq.mm or 2.5 Sqmm multi stranded copper conductor for control wiring and 6sq.mm for CTs and for PTs and suitably sized for power wiring with a minimum of 4 Sq.mm copper.

Wire color shall be Red, Yellow, Blue for respective Phases/PT wires, Black for neutral, Green / Yellow for earthing circuits, Grey for control wiring etc.

22.13 Terminal Blocks

Terminal blocks shall be colour coded 750V grade, 10Amps rated, one piece moulded, complete with insulated barriers, stud type terminals, washers nuts and lock nuts and identification strips. Markings on the terminal strips shall correspond to wire numbers on the wiring diagrams.

Terminal blocks for CT and PT secondary leads shall be provided with test links and isolating facilities. Also, CT secondary leads shall be provided with short circuiting and earthing facilities.

Not more than one wire shall be terminated on either side of a terminal. When it is required to terminate two or more wires on the same terminal, the wires shall be terminated on adjacent terminals and these terminals shall be shorted using suitable shorting links.

At least 20% spare terminals shall be provided on each panel and these spare terminals shall be uniformly distributed on all terminal blocks. This shall include 10% spare terminals for inter cubicle wiring also.

Sufficient number of spare contacts and terminals of the panel mounted equipment and devices shall be wired to terminal blocks.

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Protective covers of transparent plastic for placing over live parts of the terminal blocks shall be provided.

There shall be a minimum clearance of 250mm between the first row of terminal blocks and the associated cable gland plate. Also, the clearance between two rows of terminal blocks shall be a minimum of 150mm.

Moulding terminals shall be self extinguishing or resistant to flame propagations, substantially non-hygroscopic and shall not carbonise when tested for tracking. The insulation between any terminal & framework or between adjacent terminals shall withstand a test of 2kV for one minute. The mouldings shall be mechanically robust to withstand handling while making terminations.

Suitable barriers shall be provided between two terminals connected to different voltage supplies.

22.14 Interposing Relays

Necessary interposing relays and hardware as required shall be provided. Each feeder shall be provided with interposing relays for start / stop / selection if any.

22.15 Arc-Flash Protection:

Arc fault protection shall be employed for the fast clearance of arcing faults on busbars and within metal clad switchgear and associated cable boxes caused by human errors during maintenance or insulation breakdown during operation etc.

The lens sensors shall be placed in busbar compartment, breaker compartment, and cable compartment of the metal-clad cubicle.

Numerical protection relays shall be equipped with arc-flash protection option. In practice this means sensor inputs to which the arc flash sensors can directly be connected.

22.16 Cable Boxes & Glands

Cable terminating boxes along with termination kits shall be supplied complete with all accessories. Cable box shall withstand the short circuit rating of the switchgear. Cable termination kits shall be heat shrinkable / cold shrinkable type.

Necessary number of cable glands/lugs shall be provided for terminating power and control cables.

22.17 Plug Point

A 240V, 1 phase, 50Hz, AC plug point shall be provided in the interior of each breaker feeder with an on-off switch for connection of hand lamps.

22.18 Interior Illumination

Metering/wiring cubicle shall be provided with LED / CFL fitting for illumination of each feeder breaker.

22.19 Tests & Test Reports

Routine tests shall be carried out on completely assembled equipment as per relevant standards.

Functional tests shall be carried out to demonstrate the specified control and interlocks.

Copies of the test certificates for all brought out items shall be submitted for the PURCHASER'S approval.

Oscillographic test records for closing and tripping timings of the breakers shall also be furnished.

The contractor shall furnish copies of all valid type test reports as per the relevant standards. Type tests shall be carried out free of cost to prove the design if not tested in the previous five years.

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22.20 Employer's Specifications

Sl. No.	Description	Unit	Client's Specification	
			11 kV	**33 kV**
1	**Switchboard cubicles and Bus bar ratings**			
1.1	Nominal voltage, phases, and frequency	V, Ph, Hz	11000 V, 3Ph, 50 Hz	33000 V, 3Ph, 50 Hz
1.2	System neutral earthing		Non-Effectively	
1.3	Maximum system voltage	V	12000	36000
1.4	Type of breaker		VCB	
1.5	One minute power frequency withstand voltage	kV(rms)	As per Standard	
1.6	1.2/50 microsecond impulse withstand voltage	KV (peak)	As per Standard	
1.7	Bus bar support insulator	kV	12	36
1.8	Bus bar rating	A	Refer SLD	
1.9	Short circuit current rating and duration	kA / Sec	Refer SLD	
1.10	Dynamic rating		Refer SLD	
2	**Constructional**			
2.1	Thickness of sheet steel enclosures, doors and covers	mm mm	2.0 mm (Cold rolled) 2.5 mm (Hot rolled)	
2.2	Degree of protection		Bus bars – IP X4	
			Others – IP X6	
2.3	Colour finished shade (Enamel / epoxy)		Interior: Glossy white Exterior: RAL 7035	
2.4	Material of earthing bus	Mm x mm	50x10mm GS flat (Minimum)	
2.5	Minimum clearance in air of live parts	mm	Phase to Phase – IS/IEC	
		mm	Phase to Earth – IS/IEC	
3	**Breaker**			
3.1	Circuit breaker type		VCB	
3.2	Voltage, frequency and No. of phases	kV/ph/Hz	11000kV/ 3 Ph / 50 Hz	33000kV/ 3 Ph / 50 Hz
3.3	Rated operating duty		O-0.3sec-CO-3min-CO	
3.4	Total opening time		3 cycles	
3.5	Total closing time		5 cycles	
3.6	Trip free operating mechanism type		Motor charged spring. Manual trip and close facility to be provided.	

Sl. No.	Description	Unit	Client's Specification	
			11 kV	**33 kV**
3.7	Short circuit current rating and duration		Refer SLD	
3.8	Auxiliary control voltage:			
i)	For closing / tripping coil / spring charging motor	V, DC	220V +10% volts	
ii)	For space heaters and lighting and plug point	V, Phase	240V +10%, 1 phase	
4	**Current transformer**			
4.1	Type		Cast resin bar primary	
4.2	System voltage and frequency	V, Hz	11000 V, 50 Hz	33000 V, 50 Hz
4.3	Class of insulation		Class 'B' or better	
4.4	Short circuit withstand current and duration		Refer SLD	
4.5	Rated Primary current & ratio		As per SLD	
4.6	Accuracy class & Burden		As per SLD	
5	**Voltage transformer**			
5.1	Type		Cast resin	
5.2	Rated voltage -			
i)	Primary	V	11000 /√3	33000 /√3
ii)	Secondary	V	110/√3 / 110/√3	
5.3	Method of connection -			
i)	Primary		Star earthed	
ii)	Secondary		Star / Open	
5.4	Rated voltage factor		1.2 Continuous & 1.9 for 30secs	
5.5	Class of insulation		Class 'B' or better	
5.6	Accuracy Class		Metering – 0.2 Protection – 3P	
5.7	Burden		As required	

22.21 Applicable Standards

Sl No	Item	Standard	Standard
1	Circuit Breakers	IS/IEC 62271-100	
2	Metal Enclosed Switchgear	IEC 62271-200	
3	Current Transformers	IS 2705	IEC 61869-2
4	Voltage Transformers	IS	IEC 61869-3
5	Arrangement For Switchgear Busbars, Main Connections and Auxiliary Wiring	IS 5578 / IS 11353	
6	Busbar Support Insulators	IS 2544	IEC 60273
7	Degree Of Protection	IS/IEC 60529	
8	Electrical Relays for Power System Protection	IS 3231	IEC 60255
9	Electrical Indicating Instruments	IS 1248	IEC 60051
10	High Voltage Fuses	IS 9385	IEC 60282
11	A.C. Electricity Meters	IS 1595	IEC 60359
12	Aluminium Busbars	IS 5082	IEC 60105
13	Code Of Practice for Phosphating Iron and Steel	IS 6005	IEC 255
14	A.C Disconnectors and Earth Switches	IS/IEC 62271-102	
15	Low Voltage Fuses	IS/IEC 60947-3	

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22.22 Mandatory Spares

Sl. No.	Description	Quantity
1	**MV Switchgear**	
1.1	Breaker Close Coil	2 Nos of each type & rating
1.2	Breaker Trip Coil	2 Nos of each type & rating
1.3	Breaker Spring Charge Motor	2 Nos of each type & rating
1.4	Current Transformer	1 set of each type & rating
1.5	Voltage transformer	1 set of each type & rating
1.6	HT Fuses	3 set of each type & rating
1.7	Gas Filling device Kit	1 Set
1.8	MCB/MCCB	5 Nos of each type & rating
1.9	Indication Lamps	10 Nos of each type & rating
1.10	Protection relay	1 No of each type & rating
1.11	Meters	1 No of each type & rating
1.12	Push button	5 No of each type & rating
1.13	Contactors	5 Nos of each type & rating
1.14	Interposing relay (IPR)	10 Nos. of each type & rating
1.15	Terminal Blocks	2 sets of each type & rating
1.16	Internal wiring control cables	1 coil for each type
1.17	Circuit breaker complete set	1 no. of each type used.

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CHAPTER 23: LV SWITCHGEAR

23.1 Scope of Work

This specification covers the design, material, construction features, manufacture, inspection, and testing at VENDOR's/SUB-VENDOR's works, delivery to site, installation, commissioning and performance testing of metal enclosed Low Voltage switchgear for voltage not exceeding 1000 V AC.

The switchgear would comprise Power Control Centres (PCCs), Motor Control Centres (MCCs), Power cum Motor Control Centres (PMCCs), AC distributions boards (ACDBs), Local push button station required for the supply of power and control of the plant low voltage equipment.

The LV switchgear shall be designed to handle all the power at 415V level. The LV switchgear scheme shall be as per LV Switchgear Schematic including all required provisions for interlocking scheme.

The 415 V LTAC switchgear shall be required to supply station and other auxiliary power. Station

23.1.1 Auxiliary Board:

Station Auxiliary Board shall be divided into four section SAB-1, SAB-2, SAB-3 , SAB-4 with bus coupler provision (normally open). Each Section shall be fed from respective station auxiliary transformer.

23.1.2 Unit Auxiliary Board:

Unit Auxiliary Board shall be provided to cater the auxiliary load of generating unit. Six nos UABS are considered, one UAB for each Unit loads. Each UAB is fed from two sources i.e UAT and SAB.

23.1.3 Dam site/Tailrace/ Intake/Surge shaft Distribution Board:

All respective area DBS shall be provided to cater the auxiliary load etc loads of respective locations Each DB is fed from two supplies i.e Application transformers and DG set at respective location. Each distribution board is considered with two point of incoming Supply (one from transformer and one from DG Set)

23.1.4 Pothead Distribution Board:

Pothead DB shall be provided to cater the auxiliary load of pothead yard auxiliary loads.

23.1.5 List of Unit Auxiliary Board – 415V

UAB-1: From Unit 1 (415V)

UAB-2: From Unit 2 (415V)

UAB-3: From Unit 3 (415V)

UAB-4: From Unit 4 (415V)

23.1.6 List of Station Auxiliary Board – 415V

SAB-1: Powerhouse control block. (415V)

SAB-2: Powerhouse control block. (415V)

SAB-3: At Generator floor. (415V)

SAB-4: At Transformer Hall cavern. (415V)

23.1.7 List of Local Distribution Board – 415V

Local DB-1: At Tail race outfall. (415V)

Local DB-2: At Dam site. (415V)

Local DB-3: Chapangchhu intake. (415V)

Local DB-4: Surge Shaft. (415V)

Local DB-5: Butterfly valve area. (415V)

Local DB-6: At Pothead yard. (415)

23.2 Codes & Standards

The design, material, construction, manufacture, inspection, testing and performance of equipment shall comply with all currently applicable standards, codes of practice, regulations and safety codes in the locality where the equipment will be supplied & installed. Nothing in this specification shall be construed to relieve the CONTRACTOR of this responsibility.

The codes and standards mentioned in the various specifications and requirements specified in the enquiry document shall be latest as on the day of award of contract of the works unless otherwise specified. Contractor shall be responsible to inform to the Consultant/ Owner in case of any revisions/re-affirm/amendment in the relevant codes and standards after the date of award of contract within 30 days of the issue of such revision/re-affirm/amendment of the code/ standard. Consultant/ Owner may approve use of the earlier code/ standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed

In case of conflict between the applicable standards and this specification, the more stringent of the two shall govern.

23.2.1 LV Switchgear Panels

The following list of switchgears are covered under is specification. Additional details refer data sheet-A:

i) Unit Auxiliary board

ii) Station Auxiliary board

iii) Valve house DBs

iv) ACDB

v) Any other switchgear/distribution board as per project requirement and refer SLD

The preliminary details such as continuous current rating of the bus bar, feeders, minimum protection relays, and meters, etc to be provided as shown in the Single line diagram. The Contractor shall review the rating of equipment required for the system offered, the protection relays and meters for effective protection and monitoring of the equipment being supplied and add additional relays/meters and suitable rated equipment as required.

The complete switchgear shall be procured from the same source to ensure interchangeability of components.

The switchboards shall derive power from the designated service transformers or from emergency DG set or from switchgear panels.

The incomer breakers from auxiliary transformer and DG set shall be provided with auto-changeover facility in the event of failure of an incomer supply. It shall have the option of momentary paralleling facility.

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The LV switchgear shall be provided with adequate number and type of outgoing feeders as required for TG auxiliary drives, crane, gates, lighting, heating, GIS, BOPs, etc. of the plant. Starters/LPB station for various drives shall be included in the scope as required. The LPB station shall be complete with start/ stop push buttons, indicating lamps, adequate NO/NC contacts, terminal block, control wiring, etc.

23.2.2 Spare feeders

i) 20% of each type and each rating with minimum of one no. feeder per board

ii) Bus VT module - 1 no.

iii) Switchboard 240V, 1 phase space heating

iv) 240V, 1 phase motor space heating supply module

v) Any other system / equipment which require power supply

vi) Line VT module - 1no for each incomer

vii) MFM for incomer and ACB operated outgoing feeders.

Necessary transducers shall be supplied and mounted as per single line diagram in the switchgear panel. Transducers shall have 4–20mA dual output and accuracy class shall be less than 0.5%

The switches, breakers, contactors, and other power devices shall consider a margin of about 20% over the name plate current rating of the respective load.

Air circuit breakers shall be provided for all feeders rated 400A & above and MCCBs with OV/UV/EF release shall be provided for feeders rated between 63 A & above and less than 400A. MCCB/MCB shall be provided for the feeders rated below 63A as per panel short circuit rating.

i) ACB for Motor rated ≥ 110kW

ii) MCCB with separate OLR - DOL Starter for Motor rated >30kW & < 110 kW

iii) MPCB with DOL Starter for Motor rated <30kW.

iv) 24V* Interposing relays shall be provided for control from remote / SCADA.

23.3 Constructional Features

The switchgear shall be indoor, metal enclosed, floor mounted of uniform height not more than 2450 mm, made up of the requisite vertical sections.

The frames shall be sheet steel enclosed and shall be dust, weather and vermin proof providing a degree of protection of - IP 52 up-to & equal to1600A and IP42 above 1600A for indoor use and IP 55 for outdoor use. Sheet steel used shall be cold rolled and at least 2.5 mm thick and properly braced to prevent wobbling.

The degree of protection provided by enclosures against external mechanical impacts shall be IK08 minimum. Panels shall be supplied with base channel (Minimum ISMC 75/ 100) which will be an integral part of the panel.

Adjacent switchgear cubicles shall be provided with side sheets on either side to ensure complete isolation. The switchgear shall be easily extendable on both sides by the addition of vertical sections.

Proper gasketing shall be provided all around the perimeter of adjacent panels, panel and base frame, removable covers and doors. Gaskets shall be EPDM type.

From internal isolation point of view, the switchgear shall be designated in the following form of separation:

i) Form 3 : Separation of busbars from the functional units

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ii) Separation of all functional units from one another

iii) Form 3a : Terminals not separated from bus bars

iv) Form 3b : Terminals separated from bus bars

v) Please refer Data sheet - A for the specified form of separation

vi) Fully Draw out Type withdraw able Chassis:

The chassis housing feeder for motor control equipment except circuit breakers/common control transformers of big size, shall be of the fully draw-out as specified.

In this type of construction it shall be possible to draw out the chassis without having to unscrew or unbolt any connections to the equipment mounted on the withdrawable chassis. The power and control drawout type connections shall be of sliding type. All drawout contacts, including for auxiliary and control wiring shall be of self-aligning type.

All identical equipment and corresponding parts including chassis of drawout modules of the same size shall be fully interchangeable, without having to carry out modifications.

The draw-out contacts shall be made of copper/ copper alloy/aluminium faces, which shall be silver or tinplated.

For draw out modules, only handles of control and selector switches, push buttons, knobs and cutouts for lamps and meters shall be put on front door of respective compartments. All other components shall be on with-drawable chassis.

Switchgear / MCCs shall be divided into distinct vertical sections of:

i) Completely enclosed busbar compartment running horizontally

ii) Individual feeder modules in multitier arrangement. Module height shall be minimum 200mm

iii) Enclosed vertical busbars serving all modules in vertical section.

iv) Vertical cable alley covering entire height and minimum 250mm wide.

v) A horizontal separate enclosure for all auxiliary power and control bus, if required.

vi) Separate metering compartment for ACB feeders.

vii) No equipment requiring operation shall be located less than 250mm from bottom level of the panel (ground level).

viii) Each vertical section shall be equipped with space heater with thermostat.

ix) Cable alley shall be provided with suitable hinged doors.

x) All doors shall be with concealed type hinges and captive screws.

23.4 Main and Auxiliary Buses:

Switchgear/MCC bus bars shall be of uniform cross section throughout the length and made of high conductivity, Aluminium /aluminium alloy of E91 grade.

Busbars shall be sleeved, and with proper clearances, adequately supported to withstand stresses developed due to short circuits. Material used for sleeving shall be capable of withstanding maximum temperatures specified in technical requirements table. Supports shall be of glass reinforced phynolic material or cast resin. Busbar joints shall be shrouded with moulded epoxy shrouds. The busbar rating of the 415V switchgear shall be rated 1.25 times the incomer breaker rating and for tapoff busbars, the current rating shall be at least equal to total of corresponding connected breaker(s) rating.

Switchgear / MCC shall be designed such that all component equipment and busbars operate satisfactorily without exceeding their respective maximum permissible temperature limits.

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Busbars shall be adequately supported on insulators. These shall withstand dynamic stresses due to short circuit currents specified.

Size of the vertical busbars in each vertical section shall be such that it shall carry minimum 80% of the sum of the connected load to that vertical bus.

In case of busduct termination at the incomer, flange arrangement as per requirement of busduct Vendor shall be considered.

23.5 Painting

Panel shall be complete with all fabrication work like drilling, punching, shearing and welding etc. before proceeding to pre painting processes.

Pre-treatment of all sheet steelwork, including degreasing, acid pickling, de-rusting, phosphating, passivation including repeated rinsing in between each process shall be carried out as per applicable standard.

After Pre-treatment, the panel shall be provided with protective coating including compatible primer with the shade as indicated in Data Sheet A1 for exterior and interior with minimum thickness of 80 microns DFT.

After coating, Curing shall be carried out as per the required process. Any post painting fabrication activity like drilling, cutting, welding may liable for rejection of complete panel.

23.6 Control Supply

415/110V Control transformers of 2 x 100% capacity shall be provided for the bus for deriving control supply at 110V AC, 1 phase.

Incomers, buscouplers, or any changeover operation required, shall be provided with DC supply and all other outgoings / starters shall be provided with 110 V AC supply.

DP MCB shall be provided for all control circuits where the fault level is less than fault withstand capacity of MCB. Else the control supply shall be tapped through a control transformer of adequate capacity supplied with MCCB/ MPCB / SFU of adequate short time rating. Independent DP MCBs shall be provided for each circuit such that tripping due to fault in one circuit should not affect other functions adversely. The insulation class for control transformer shall be Class B

Where control transformer has been provided, a separate control bus shall be run maintaining adequate clearance of atleast 300mm from the power bus with provision of tapping at each vertical column section. The control bus should be preferably a bus bar with Heat shrinkable sleeve.

23.7 Safety Interlocks and Features

Withdrawal or engagement of circuit breakers or switch (isolator) shall not be possible unless it is in the open position.

Operation of circuit breaker shall not be possible unless it is fully in service positions or in test position or is fully drawn out.

Circuit breaker cubicles shall be provided with safety shutters operated automatically by the movement of the circuit breaker carriage, to cover the exposed live parts when the breaker is withdrawn.

Caution name plate with inscription "Caution - Live Terminals" shall be provided at all points where the terminals are likely to remain live and isolation is possible only at remote end, e.g. incoming terminals.

A breaker of given rating shall be prevented from engaging with a stationery element of higher rating.

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Padlocking provisions shall permit locking the circuit breaker in either the “test” or “disconnected” position.

Control cabinets shall be provided with hinged door(s) with padlocking arrangement suitable for use of Lock out Tag out (LOTO) equipment. The doors shall move in the horizontal plane and handles for the switches shall be on the door itself. Only one door shall be provided for the switching and fuse chamber.

Easy identification (separate color) of couplers breaker panel to avoid safety incident.

Bus coupler and incomer breaker bus-bar compartment back door opening should have safety interlock (Back door should not open if bus is live)

Cable back charge indication on back side.

23.8 Air Circuit Breakers

Mechanically operated targets to show 'Open', 'Closed', 'Service' and 'Test' positions of the circuit breaker. Padlock devices shall be provided to control opening/closing and racking in/out of the circuit breaker

Locking facilities in the 'Service', 'Test', and 'Isolated', positions.

Closing and trip coil shall operate satisfactorily under the following conditions of supply voltage variation: Closing coils - 85% to 110% of rated voltage & Trip coils - 70% to 110% of rated voltage.

When series trip circuit breakers are specified the following microprocessor releases with adjustable settings shall be provided: (a) Overload (b) Short circuit (c) Under voltage (d) Earth fault.

For four pole breaker the microprocessor-based earth fault release shall be in built. For TPN breaker the microprocessor-based earth fault release shall be in built with input from a separate neutral CT.

Facilities shall be provided for blocking the under-voltage release, if so, required at Site.

The breakers controlling motors shall operate satisfactorily under following conditions: (a) Direct-on-line starting of the specified motor. (b) Breaking no load current of the specified motor.

The operating mechanism shall be manually operated spring charging stored energy type & with motor, opening, and closing springs, limit switches for automatic charging and all necessary accessories. Facility for manual charging of the closing spring shall be provided. The operating mechanism shall be trip-free and non-pumping electrically.

All ACBs shall be with Icu=Ics=Icw=100%.

23.9 Protection Coordination

It shall be the responsibility of the Vendor to fully coordinate the overload and short circuit tripping of the circuit breakers with the upstream and downstream circuit breakers/fuses/motor starters, to provide satisfactory discrimination. Protective releases shall be EMC compliant. The release shall be protected against non-linear loads and shall not cause nuisance tripping due to harmonics. All protective components esp. ACBs and MCCBs installed in PCC and at Incomer of downstream Panels shall be with Utilization Category "B" (i.e. offering time discrimination with downstream devices)

23.10 Moulded Case Circuit Breakers (Mccb)

MCCBs in AC circuits shall be of triple/four pole construction arranged for simultaneous three/four pole manual closing and opening. Power closing device for remote operation shall be provided, if necessary. Operating mechanism shall be quick-make, quick-break and trip-free type. All MCCBs shall be provided with rotary operating handle with door interlock feature.

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The instantaneous short circuit release shall be so chosen by the VENDOR as to operate at a current in excess of the peak motor inrush current and a range of settings shall be provided for the PURCHASER'S selection.

All MCCB's shall be with Icu=Ics=100%.

All the MCCBs shall be of current limiting type and shall provide a cut off in, < 10 ms for prospective currents during faults.

The MCCB's shall be provided with thermal magnetic or microprocessor based overload, short circuit and earth fault releases as required & specified. For four pole MCCB the microprocessor-based earth fault release shall be inbuilt. For TPN MCCB the microprocessor-based earth fault release shall be inbuilt with a separate neutral CT input or the earth fault protection shall be provided by CBCT, ELR and shunt trip coil. For thermal magnetic release the earth fault protection shall be provided by CBCT, ELR and shunt trip coil.

23.11 Relay

Numerical protective relays with communication facility for SCADA interconnection. Relays shall be in draw-out cases with built-in test facilities or plug in type with proper testing facilities. Numerical protective relays should have conformal coating.

The tripping relays shall be latch-in type with hand reset facility and shall preferably have operating time not exceeding 20 ms.

23.12 Meters

All the meters shall be digital type including Ammeter & Voltmeter. All digital meters shall indicate true RMS. Digital Multifunction meter shall display all electrical parameters like (but not limited to) following metering features : Current, Voltage, Frequency, Energy (kWh), MD (kW/kVA), PF, kVAh, kVAr, kVARh, V THD, I THD, etc. Multi-function meters with communication facility for SCADA interconnection, etc.

MFM Meter where ACBs provided for all feeders / incomers.

For Motor rated 30 kW and above, ammeter & ammeter transducer shall be considered. For outgoing power feeder ammeter shall be considered for 100A and above.

Emergency MCC feeders shall be provided with ammeter and ammeter transducer irrespective of motor rating.

All analog values to be provided on SCADA or HMI in control room.

23.13 Module Details

23.13.1 Incomers & Bus Couplers

The incomer modules of 415V switchgear shall be ACB/MCCB controlled. They shall be provided with following minimum requirements:

i) Dedicated CTs for metering and protection

ii) MCCB/MPCB for 220V DC control supply

iii) Breaker control switch

iv) Local remote selector switch

v) Service & test position limit switches with required no. of contacts

vi) phase inverse time over current relays & 1 no. of E/F relay (Numerical type with communication capability)

vii) Lock out relay with supervisory lamps.

viii) Indicating lamps for on, off and fault

ix) Necessary circuitry and devices for auto trip, fault alarm, auto changeover of supplies and for control/ alarm of the breaker as required.

x) IPRs for the SCADA / PLC control

The incomer modules shall be interlocked with their upstream breakers such that they can be closed only when upstream breaker is closed and trips automatically when upstream breaker is tripped.

All hardware required for meeting the functional requirements stated above, whether specifically listed out in the specification or not, shall be included in the Contractor's scope of supply.

23.13.2 VT Modules

Bus VT modules shall be provided with suitable 415/√3/110/√3V VTs with MPCB/MCCB on primary and MCB on secondary.

The bus VT module shall be provided with one voltmeter with selector switch. The accuracy class of VT shall be 1.0 with adequate VA burden. Bus voltage should be available on remote HMI at control room.

23.13.3 Motor Modules

The motor modules shall be provided with

i) MCCBs, air brake contactors, thermal overload relays with integral single phasing for motors up to 110kW ensuring type-2 co-ordination.

ii) ACB and composite numerical motor protection relay for motors above 110KW rating ensuring type 2 co-ordination with dedicated CT's.

iii) Breaker on, off and trip indicating lamps.

iv) Necessary auxiliary contactors for fault alarm circuit, 240V space heating circuit.

v) Module 'ON', 'OFF', PBs for non-reversible modules and 'FORWARD' 'REVERSE' and 'OFF' PBs for reversible modules.

vi) Appropriate circuitry for receiving the on, off and forward-reverse commands from remote panels/ systems, interlocks, off command from local push buttons, etc.

vii) MCB for space heating/winding heating circuit.

viii) O/L Relay reset facility on the main door.

ix) The modules for motors rated 30kW and above shall have a CT and an ammeter. A Transducer shall be provided for remote metering.

x) IPRs for the SCADA / PLC control.

xi) The motor modules rated 30kW and above shall be provided with 240V, 1 phase space heating arrangement.

xii) Adequate number of starter panels as required shall be included.

23.14 Internal Wiring

All wiring shall be carried out with 1100V grade, single core, FRLS-PVC, flexible multi stranded copper conductor wires and shall be vermin and rodent proof.

The internal wiring shall be with 1.5sq.mm multi stranded copper conductor for control wiring and 4 sq.mm for CTs & 2.5 sq.mm for PTs and suitably sized for power wiring with a minimum of 2.5 Sq.mm copper.

Wire color shall be Red, Yellow, Blue for respective Phases/PT wires, Black for neutral, Green / Yellow for earthing circuits, Grey for control wiring etc.

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Power circuit wiring minimum 4.0 Sq. mm Red, Yellow & Blue colour for Ph and Black for Neutral wire.

All power wiring for rating up to and including 63A shall be carried out with multi stranded copper wires duly crimped with ring type lugs. Power connections for rating above 63A shall be done with bus bars (machine bend for proper profile) insulated with black heat shrinkable sleeves.

Terminal blocks shall be of stud type, 1100 volts grade, 10 amps. rated complete with insulated barriers. Terminal blocks for CTs and VTs shall be provided with test links and isolating facilities and CT terminals shall have short circuiting and earthing facility. Terminals shall be suitable to take up two numbers of 2.5 sq. mm. copper wires. All terminals of different control voltages shall be separate from each other. Suitable barriers shall be provided between two terminals connected to different voltage supplies. 20% spare terminals to be provided for each terminal strip for each panel.

23.14.1 415v / 240v A.C. Distribution Board / Control Panel

Bidder shall include in his scope required no. of 415V AC and 240V AC power supply distribution board/control panel for feeding packaged auxiliary load if any. Bidder shall provide incomers from 415V main switchboard to feed the distribution board/control panel. All the incoming and outgoing feeders shall be of MCCB /MCB controlled depending on the fault level.

A.C. distribution boards / control panels shall be provided with thermostatically controlled space heater, cubicle lamp and power plug.

23.14.2 Cable Termination

Glands shall be of heavy duty brass castings, machine finished and complete with check nut, washers, neoprene double compression ring etc. The lugs shall be tinned copper/aluminium depending on cable conductor and of solder-less crimping type.

23.15 Arc Resistance

The switchgear assembly shall be certified as Arc Resistant. The minimum arcing duration used for testing shall be 500ms as specified in the applicable standard.

23.16 Local Push Buttons/ Pb Stations

The local P.B. stations shall be metal enclosed, provided with IP-55 protection, made up of die-cast aluminum or 2 mm thick sheet metal.

Start push button shall be recess type, spring return. Stop push button shall be stay-put lockable type with Mushroom head.

23.17 Earthing

An earthing bus shall be provided at the bottom and extended throughout the length of the switchgear. It shall be bolted / welded to the frame work of each unit and each breaker earthing bar.

All non-current carrying metal work of the switchgear shall be effectively bonded to the earth bus. Hinged doors shall be earthed through flexible earthing braid.

Positive earthing of the circuit breaker frame shall be maintained both in service and test position.

23.18 Maintenance Requirements

Easy access shall be provided for all components in the switchgear for maintenance

As far as possible the switchgear shall be so designed that no special tools are necessary for installation and maintenance. However, if special tools are required, the Bidder shall include price of one complete set in his bid.

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Telescopic trolley or suitable arrangement shall be provided for maintenance of circuit breaker module in a cubicle. The trolley shall be such that the topmost breaker module can be withdrawn on the trolley and can be lowered for maintenance purpose. The telescopic trolley shall be such that all type, size and rating of breaker can be withdrawn / inserted.

23.19 Tests

Routine tests shall be carried out on completely assembled equipment as per relevant standards.

Functional tests shall be carried out to demonstrate the specified control and interlocks.

Copies of the test certificates for all brought out items shall be submitted for the PURCHASER'S approval.

Oscillographic test records for closing and tripping timings of the breakers shall also be furnished.

The contractor shall furnish copies of all valid type test reports as per the relevant standards. Type tests shall be carried out free of cost to prove the design if not tested in the previous five years.

23.20 Employer's Specification

Sl. No.	Description	Unit	Client's Specification
1	**Switchboard & Bus bars**		
1.1	Rated voltage, phases & frequency	V/P/Hz	415V, 3-PH, 50Hz, 4 wire
1.2	System neutral earthing		Effectively earthed
1.3	One minute power frequency voltage withstand		
1.4	Power circuits	V	2500
1.5	Control circuits	V	1500
1.6	Auxiliary circuits	V	2000
1.7	Reference ambient air temperature	ºC	50
1.8	Material of bus bars		Aluminium/Aluminium Alloy
1.9	Maximum temperature of bus bars contacts, droppers at site reference ambient of 50ºC	ºC	85ºC for non-silver plated joints 105ºC for silver plated joints
1.10	Short circuit withstand		
1.11	Short time current (1 sec.)	rms	50kA
1.12	Momentary current	Peak	105 kA
1.13	Switchboard / MCC Construction		
1.14	Form of separation		Form – 3b
1.15	Fully draw out		Fully draw out for Switchgear / MCCs Fixed type for DBs
1.16	Double front / single front		Single / Double Front (based on layout constraint)
1.17	Cable entry (Power & Control)		Bottom
1.18	Modular construction		Yes
1.19	Degree of protection		IP 52 < 1600 A IP 42 >1600A IP 55 for outdoor use
1.20	Thickness of sheet steel		Frame / Door / Cover
1.21	Cold rolled	mm	2.5 / 2.0 / 2.0
1.22	Hot rolled	m	2.5 / 2.0 / 2.0
1.23	Clearances in air for live parts		

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Sl. No.	Description	Unit	Client's Specification
1.24	Phase to Phase	mm	25.4
1.25	Phase to Earth	mm	19.4
1.26	Paint shade		RAL 7035
1.27	Contactors & O/L relay		
1.28	Utilization category for contactors		AC3 for non-reversible & AC4 for reversible
1.29	Contactor rated duty		Uninterrupted
1.30	Reset feature for thermal O/L Relay		Hand
1.31	Starter type		DOL / Star- Delta
1.32	Circuit breakers		
1.33	Circuit breaker type		
1.34	Rated operated duty		O–3 MIN–CO-3 MIN-CO
1.35	Type of operating mechanism		Motor wound spring charged
1.36	Short circuit rating		50 kA for 1 sec
1.37	Control voltage for spring charging motor	V	240 V, AC
1.38	Control voltage for tripping & closing	V	220 V, DC
1.39	Emergency manual operation required in addition to electrical operating devices		
1.40	For spring charging & closing		Yes
1.41	For tripping		Yes
1.42	Min. no. of Aux. contacts		2NO + 2NC (After use by BIDDER in all control and protection circuits)
1.43	Auxiliary control voltage for space heater, DC failure annunciation, motor winding / space heaters, lighting etc	V, AC	240
1.44	Moulded case circuit Breakers (MCCB)		
1.45	Voltage, frequency & no. of phases		415V,50Hz & 3ph
1.46	Rated operating duty		Category B
1.47	Rated short-time withstand current and time		50 kA for 1 sec
1.48	Rated current at site reference ambient temperature		As per SLD

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Sl. No.	Description	Unit	Client's Specification
1.49	On/off operation : Manual Remote power operated (Motorised)		 Yes No
1.50	Releases required		THERMAL MAGNETIC BASED
1.51	Protection		MCCB with Overload and short circuit protection
1.52	CTs and VTs		
1.53	Short time withstand current and duration for CT		50kA for 1 sec
1.54	Breaker controlled		Based on breaker short circuit current rating and duration
1.55	Switch fuse controlled		To match with fuse withstand
1.56	Overvoltage withstand capacity for VT	p.u.	1.2 continuous and 1.9 for 30 seconds
1.57	Type		Cast Resin
1.58	Accuracy class		Class E or better
1.59	Meters		
1.60	Type		Digital multifunctional meters with communication facility
1.61	Class of accuracy		1.0 for other meters, 0.5 for energy meters & TVM
1.62	Earthing bus	mm x mm	25x6 Copper Flat (min)
1.63	415V AC Distribution Boards / Control Panels		
1.64	Location / mounting		Indoor / floor mounted
1.65	Current rating		Max. expected load current + 20% margin
1.66	Cable entry		Bottom
1.67	Design ambient temperature	ºC	50
1.68	Codes and standards		As indicated for 415V switchboards / MCCs.

23.21 Applicable Standards

Sl. No.	Item	Standard
1	Low voltage switchgear and control gear assemblies-general rules	IS/IEC:61439-1
2	Low voltage - AC circuit breakers	IS/IEC 60947-2
3	Automatic power factor correction panels for voltages up to and including 1000V	IS:16636
4	Air break switches	IS:60947-3
5	Current transformers	IS:2705, 16227 (P-2)
6	Voltage transformers	IS:61869
7	Low voltage switchgear and control gear - general rules	IS/IEC:60947-1
8	Code of practice for installation and maintenance of switchgear	IS:10118
9	Code of practice for phosphating iron and steel	IS: 6005
10	Guide for testing under conditions of arcing due to internal fault	IEC 61641
11	Testing guide	ANSI/IEEE C.37.20.7

23.22 Mandatory Spares

Sl. No.	Description	Quantity
	LV Switchgear	
1	MCCB with Accessories	5 Nos of each type & rating
2	MPCB with Accessories	5 Nos of each type & rating
3	Overload Relay (OLR)	5 Nos of each type & rating
4	Contactors	5 Nos of each type & rating
5	Current Transformer	5 Nos of each type & rating
6	Voltage Transformer	3 Nos of each type & rating
7	Fuses	10 Nos of each type & rating
8	MCB	5 Nos of each type & rating
9	Indication Lamps	10 Nos of each type & rating
10	Protection relay	1 No of each type & rating
11	Meters	1 No of each type & rating
12	Switches	5 No of each type & rating
13	Push button	5 No of each type & rating
14	ACB Close coil	2 Nos of each type & rating
15	ACB Trip coil	2 Nos of each type & rating
16	ACB Spring Charge Motor	2 Nos of each type & rating
17	Fixed and moving contact assemblies of breaker	2 sets of each type & rating
18	Interposing relay (IPR)	10 Nos. of each type & rating
19	Terminal Blocks	2 sets of each type & rating
20	Internal wiring control cables	1 coil for each type

CHAPTER 24: AUXILIARY TRANSFORMER

24.1 Scope of Work

This Specification covers the requirements of sizing, design, engineering, material selection, constructional features, manufacture, inspection and testing at the VENDOR'S or his SUB-VENDOR'S Works, delivery to Site including transit insurance, installation, testing & commissioning and performance testing of cast resin dry type distribution transformers up to 36kV, with all the accessories and fittings for efficient and trouble-free operation.

i) Unit Auxiliary Transformer. (4 MVA, 13.8/0.433kV- 4 Nos.)

ii) Station Auxiliary Transformer. (2.5 MVA, 11/0.433kV- 4 Nos.)

iii) Pot headyard Auxiliary Transformer (200 kVA, 11/0.433kV- 1 No.)

iv) 33kV Service Transformer, (500 KVA, 3-Ph 33 kV / 0.433kV, 4 No.)

v) 33kV Service Transformer 200 KVA, 3-Ph, 33 kV / 0.433kV, 2 No.)

vi) Station Auxiliary Transformer (5 MVA, 33/11kV, 2 No.)

vii) Excitation transformer. (1 MVA, 13.8/0.433kV- 4 No.)

viii) Any other transformer as per system requirements.

All transformer ratings mentioned herein are tentative. The vendor shall confirm the appropriate transformer ratings based on the load list during the submission of their offers.

24.2 Codes and Standards

The design, material, construction, manufacture, inspection, testing and performance of equipment shall comply with all currently applicable standards, codes of practice, regulations, and safety codes in the locality where the equipment will be supplied & installed. Nothing in this specification shall be construed to relieve the CONTRACTOR of this responsibility.

The codes and standards mentioned in the various specifications and requirements specified in the enquiry document shall be latest as on the day of award of contract of the works unless otherwise specified. Contractor shall be responsible to inform to the Consultant/ Owner in case of any revisions/reaffirm/amendment in the relevant codes and standards after the date of award of contract within 30 days of the issue of such revision/re-affirm/amendment of the code/ standard. Consultant/ Owner may approve use of the earlier code/ standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed.

The VENDOR shall ensure that instruments and gauges to be used for testing and inspection shall have valid calibration and the accuracy can be traced to National and International Standards as applicable.

24.3 General Constructional Features

i) All material used shall be of best quality and of the class, most suitable for working under the conditions specified and shall withstand the variations of temperature and atmospheric conditions, overloads, over-excitation, short-circuits as per specified standards, without distortion or deterioration or the setting up of undue stresses in any part, and also without affecting the strength and suitability of the various parts for the work which they have to perform.

ii) The transformer shall be compact and suitable for easy installation at site. It shall be of modular design, i.e. windings can be individually mounted and replaced on site.

iii) The transformer shall be provided with 4 Nos. Bi-directional cast iron rollers fitted on cross channels to facilitate the movement of the transformer in both directions.

These rollers shall be suitable for being turned through an angle of 90deg. and locked in that position when the transformer/enclosure is jacked up.

iv) Steel bolts and nuts shall be galvanized.

Transformer shall be suitable for tropical climate and shall be anti-fungal treated. It shall be capable of withstanding thermal effect and stresses caused by short circuit or voltage surges.

v) Rating and diagram plates of stainless steel shall be provided on LT box of the transformer and shall be easily accessible. Rating and diagram plate shall be riveted to the transformer enclosure at a proper height so that it is readable. The rating diagram plate shall bear details as specified in relevant standards.

vi) Lifting eyes or lugs shall be provided on all parts of the transformer, which require independent handling, during loading, unloading, assembly or dismantling.

24.4 Core

i) The magnetic circuit shall be constructed from high grade cold-rolled non-ageing grain-oriented silicon steel laminations with non-hygroscopic insulation material on both sides. The magnetic circuit shall be of “core type” Construction. The core shall be built up with ‘step-lap' configuration. The grade of laminations shall be low loss type.

ii) It shall be carefully interlaced step lap epoxy arranged yoke. It shall be metered to have low noise and losses.

iii) An adequate painting of resin coat shall cover the complete core and the clamping structure and shall protect it against corrosion.

iv) The Final assembled core shall be free from distortion. It shall be rigidly clamped to ensure adequate mechanical strength and prevent vibration during operations.

v) The core shall be provided with lugs suitable for lifting the complete core & coil assembly.

vi) The core clamping structure shall be designed to minimise eddy current loss and bolts shall not pass through the laminations for any purpose.

vii) The bandages for the core shall be of polyester tape/fibre glass, the spacers for clamping the windings shall be of high-quality rubber/fibre glass to withstand the temperature rise specified in Data Sheet A1 and the supports shall be of porcelain.

viii) The insulation structure for the core to bolts and core to clamp plates shall be such as to withstand a voltage of 2500V for one minute.

24.5 Windings

24.5.1 LV winding

i) LV Winding shall be of Copper foil, coated with class F insulation, epoxy resin reinforced with fibre glass layers pre-impregnated and casted under vacuum, to be thermally bound to the winding.

ii) The conductors shall be transposed at suitable intervals in order to minimize eddy current and to equalize the distribution of current and temperature along with windings.

iii) Insulation of LV winding shall be adequate to withstand surge voltages appearing across them as a result of transfer due to an impulse striking on HV terminals.

iv) Adequate cooling ducts in epoxy cast shall be provided in the LV winding to obtain the required cooling in axial and radial directions.

v) The resin used for winding insulation shall be non-hygroscopic. It should be possible to energise the transformer without drying even after long period of service interruption.

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vi) In case of Dyn11 transformers, neutral shall be brought out in open for solid earthing on secondary side.

vii) The winding shall be designed to reduce the out of balance forces in the transformer at all voltage ratios at all operating conditions.

viii) The winding shall be so designed that all coil assembly of identical voltage rating shall be interchangeable and field repairs to the windings can be made without special equipment's.

24.5.2 HV winding

i) HV Winding shall be of Copper wire, double layer winding, and cast under vacuum with epoxy resin. The resin shall be pure low viscosity epoxy resin, fibre glass reinforced. The resin cast winding shall be void free.

ii) Insulation of HV winding shall be Class 'F' with temperature rise limited to Class 'B'.

iii) Resin on winding shall be casted under vacuum and then pressure impregnated. It shall be thermally bound to the winding after initial curing. Casting shall be cured thermally in controlled autoclave with complete cycle and temperature (typically 145˚C for 4-6 hrs.) recommended by manufacturer / standards.

iv) The winding shall be designed to reduce to a minimum the out of balance forces in the transformer at all voltage ratios at all operating conditions.

v) The winding shall be so designed that all coil assembly of identical voltage rating shall be interchangeable and field repairs to the windings can be made without special equipment.

vi) Adequate cooling ducts in epoxy cast shall be provided in the HV winding to obtain the required cooling in radial and axial directions.

vii) HV and LV winding shall be suitably braced and supported at top as well as bottom to withstand short circuit stresses set up by surges and damage because of inertia.

viii) The resin casting process shall be carried out under the most strict and automated controlled conditions in order to ensure optimum insulating and mechanical properties.

ix) The coil finishing shall provide smooth surface eliminating dust accumulation and give effective cooling.

24.6 Enclosure

i) The enclosure shall be of CRCA mild steel sheet. The enclosure frame shall be fabricated using suitable CRCA pressed and shaped sheet steel of thickness not less than 3mm for structural members and 2mm for all doors & covers.

ii) Enclosure shall be provided with adequate doors, covers for inspection, maintenance and removal of the active parts from the enclosure.

iii) The material used for gaskets shall be cork neoprene or nitrite butyl rubber gasket. Suitable mechanical stops shall be provided to prevent excess squeezing of gaskets.

iv) The enclosure shall not have degree of ingress protection less than IP-33.

v) Enclosure doors/covers shall be pad lockable and shall have limit switch for tripping HV circuit breaker to avoid accidental contact with live parts. Instruction in three languages (English/Local language) shall be displayed on each openable door/cover.

vi) The transformer shall be natural air cooled or fan cooled as indicated in Data Sheet A1. If forced cooling is specified, cooler fan shall be isolated from live parts and shall have separate door without interlock.

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vii) An emergency trip push button of lockable type shall be provided at a prominent and convenient place near the transformer to facilitate easy tripping of HV circuit breaker feeding the transformer during an emergency.

i) The enclosure door shall be interlocked with service transformer incoming breaker such that the door can be opened only when the service transformer HV side circuit breaker is in Test/Isolated position and HV side circuit breaker can be closed only when the doors are closed.

ii) All wheels should be detachable and be made of cast iron. Wheels shall be mounted on separate ISMC (MS channel), provided at bottom of the frame.

iii) Lifting eyes or lugs shall be provided on all parts of the transformer, which require independent handling, during loading, unloading, assembly or dismantling such as core, enclosure etc.

24.7 Earthing

i) The framework and clamping arrangement of core and coil shall be suitably earthed internally to the body of enclosure. Separate 2 nos. earthing terminals shall be provided on enclosure for connection to PURCHASER's earth grid.

ii) Core shall be earthed to the frame. Suitable arrangement shall be provided for disconnecting the core earthing for insulation measurement.

iii) 2Nos. separate earthing pad / terminals shall be provided on the HV cable box for armour earthing from inside and for OWNER's grid connection from outside.

iv) Apart from the neutral leads for power connection, a separate neutral terminal shall be provided to facilitate termination of 2 nos. earthing conductors, which in turn will be connected to two (2) distinct earthing pits by direct connection. The connection may be by insulated cable or by bare strip. In case of cable connection, suitable cable box to terminate the cables shall be provided.

v) Flexible earthing braid shall be provided between all metal parts joined with gaskets.

vi) Arrangement for supporting 2 runs of GI, up to grade level, from neutral terminal connection installed outside shall be provided.

24.8 Termination

24.8.1 Transformers shall be suitable for the following terminal arrangements:

i) LV Side: - The LV side including the neutral shall be brought out through bushings and suitable arrangement for bus trunking with horizontal or vertical take-off of bus duct or cable box suitable for top/ bottom cable entry as specified in Data Sheet A1 shall be provided.

ii) HV cable box: - HV side leads shall be brought out through bushings to a cable box and cable box shall be suitable for top or bottom entry as specified in Data Sheet A1 and provided with plug-in terminals.

iii) Support insulator i.e. bushings material shall be of porcelain/ epoxy resin cast.

iv) Manufacturer shall indicate the method of connection (type of welding /brazing etc.) between the winding and the termination bar.

24.9 Marshalling Box

i) A marshalling box shall be provided for housing transformer control and other signalling equipment. The marshalling box shall be of mild steel sheet and shall be with IP 54 or better degree of protection for enclosure.

ii) The marshalling box shall be complete with necessary cable glands and cable lugs. All sensor and equipment connection shall be wired up to the terminal with ferrules.

iii) The marshalling box shall accommodate digital temperature indicator and gland plates for incoming and outgoing cables. Marshalling box shall be provided with toughened glass visor to facilitate the reading of temperature indicators.

iv) Marshalling box shall be provided with cubicle illuminating lamp along with control switch and door limit switch and a thermostatically controlled space heater. Also it shall have one 16A utility socket.

v) All spare contact and terminals shall be wired up to the terminal block. 20% spare terminals shall be provided. Terminal block shall be rated for 10A. Wiring shall be with PTFE/FRLS PVC insulated multi stranded copper conductors of sizes not less than 1.5 sq.mm for control cables and 2.5 sq.mm for CT circuits. CT terminals shall be provided with shorting and earthing facility. Printed identification ferrules shall be of yellow colour with black lettering.

vi) Control voltage shall be 220V/110V/24V DC for all equipment, as per project requirements and 230V, 1 phase, 50 Hz for utility requirements.

24.10 Painting

All interiors and exteriors of transformer/enclosure / shall be finished and painted to produce a neat, fire resistant and durable surface which would prevent rusting and corrosion. Sheet metal components shall be pre-treated using the seven-tank phosphating process consisting of de-greasing, acid pickling, de-rusting, phosphating, and passivation including repeated rinsing in between, thickness of painting shall be minimum 75-80 microns. The colour shade of the sheet metal work shall be as indicated in Data sheet A1.

24.11 Electrical and Performance Requirements

i) Transformers shall operate without injurious heating at the rated KVA at any voltage within + /- 10 percent of the rated voltage of that particular tap.

ii) Transformer shall be capable of delivering rated current at a voltage equal to 105% of rated voltage

iii) Transformers shall be designed for 110% continuous overfluxing withstand capability.

iv) Overloads shall be allowed within the conditions defined in the loading guide of the applicable standard. Under these conditions, no limitations by terminals, tap changers or other auxiliary equipment shall apply.

v) Transformer shall be self-extinguishing in the event of fire or arcing and no toxic or corrosive gases shall be released.

vi) There shall not be any risk of cracking of the epoxy casting in the transformer.

vii) Transformer shall have partial discharge level of less than 10pC.

viii) The neutral terminal of windings with star connection shall be designed for the current that can flow through this winding.

ix) Transformer shall be of low noise.

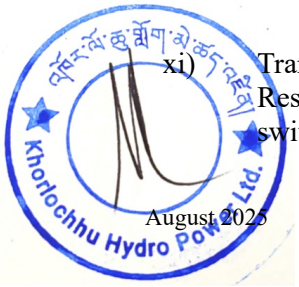
x) Transformer shall be certified for following:

a) Class for “Fire Behaviour”- As specified in Data Sheet A1 or Section C

b) Class for “Climatic”- As specified in Data Sheet A1 or Section C

c) Class for: -“Condensation and humidity”- As specified in Data Sheet A1 or Section C

xi) Transformer shall be suitable for switching with Vacuum Circuit Breakers (VCBs). Resonance frequency of the winding shall be such as to avoid resonance with the switching impulse of VCBs and overstress of the insulation.



xii) The sound level of the transformer shall not exceed the limit indicated by relevant standard under any specified operating conditions.

24.12 Fittings and Accessories

The transformer shall be provided with following fittings and accessories

i) Enclosure with Top cover

ii) Rating & diagram plate

iii) Terminal markings plate.

iv) Earthing terminals.

v) Cable box with HV plug-in connectors.

vi) Bus duct termination arrangement/ cable box

vii) Neutral cable box for neutral earthing if applicable

viii) Lifting lugs

ix) Hauling lugs

x) Base Channel

xi) Undercarriage with 4 nos. rollers, which can be turned 90 degrees and bidirectional.

xii) High-voltage danger notices against touching of coils.

xiii) Louvers

xiv) Winding Temperature indicator with RTD sensor (minimum 2 per phase). Pre-set PTC sensors shall be provided and attached to each of the LV winding as close as possible to the hottest spot. The PTC sensors shall be selected in order to protect both, HV and LV windings. Contacts for alarm and trip and shall be suitable for 220V/110V/24V D.C. The Indicators shall have a suitable RS 485 port for transfer of data to plant SCADA/DCS system).

xv) Marshalling Box.

xvi) Off Circuit Tap Changing Links

xvii) The tap-changing shall be performed by link mechanism. The links shall be accessible after opening the door/cover.

xviii) Cast resin current transformer on transformer neutral for stand-by earth fault protection, Restricted Earth fault protection, as specified in Data Sheet A1.

xix) All necessary cable glands, cable lugs, armour earthing clamps, terminal connectors, cable sealing ends and accessories required for termination of the PURCHASER's cables/ bus duct shall be included.

24.13 TESTS

24.13.1 The routine tests shall be carried out as per applicable standards and shall be deemed to be included in the VENDOR'S scope. The following additional points/tests shall also be considered as part of routine tests and included in the scope.

i) Resistance must be measured at extreme taps also in addition to principal tap.

ii) Impedance must be measured at extreme taps also in addition to principal tap.

iii) No load loss and exciting current shall be measured at rated frequency at 90%, 100% and 110% rated voltage. These tests shall be done after impulse tests if the latter are specified.

iv) No load loss and exciting current shall be measured and recorded with 415V, 3-phase, 50 Hz input on LV side.

v) Magnetic circuit (Isolation) test as per relevant standard.

vi) Measurement of zero sequence impedance

24.13.2 Type tests, if required, shall be carried out, as per applicable standards and the BIDDER shall quote extra unit prices for carrying out each of the type test.

24.13.3 In addition, if required, special Tests as listed below shall be carried out as per applicable standards and the BIDDER shall quote extra unit prices for carrying out the same.

i) Partial Discharge test

ii) Acoustic Sound Level measurement

iii) Short Circuit Test

iv) Thermal Shock Test

v) Environmental Test

vi) Climate Test

vii) Fire Behaviour Test

24.14 Spares

The BIDDER shall quote item wise prices for the spares recommended for 3 years trouble free operation or as per the agreement between VENDOR and PURCHASER.

24.14.1 Test at site

The following tests/checks on dry type transformer shall be performed by the VENDOR at site at the time of erection and commissioning if included in scope. Typical checks to be carried out at site are listed below:

i) Preliminary checks

ii) Compare nameplate details with the specifications.

iii) Check for any physical damage, in particular of support insulators.

iv) Check tightness of all bolts, clamps and connecting terminals.

v) Check cleanliness of support insulators, core coil assembly, marshalling panels, enclosure, etc.

vi) Check for clearances.

vii) Check earthing of transformer supporting structure/enclosure and neutral terminals.

viii) Check that the transformer is correctly installed with reference to its phasing and properly aligned with respect to switchgear and interconnecting external bus duct if any.

ix) Check for proper termination support of HV and power cables, and provision of cable glands for the same.

x) Check welding/bolting to embedded parts/floor of the building.

24.14.2 Commissioning checks (if included in scope)

i) Insulation resistance test of windings and polarisation index on winding.

ii) Vector group test.

iii) Phase sequence test.

iv) Winding resistance test at all taps.

v) Insulation resistance of control wiring.

vi) Core loss test at service tap.

vii) Voltage/turns ratio at all the taps.

viii) Magnetic current balance at full voltage.

ix) Capacitance and tan delta measurement.

x) Tests on current transformers

xi) Continuity test

xii) Polarity test

xiii) IR tests

xiv) Magnetization characteristics

xv) Ratio test

xvi) Secondary winding resistance measurement.

xvii) Measurement of mV drop across HV and LV power connections and joints.

24.15 Losses

Losses shall be as per standard specified in Data Sheet A1, A2, A3 and A4.

24.16 Rejection

PURCHASER may reject any transformer if during tests or service (during warranty period) any of the following conditions arise:

i) Total loss exceeds the guaranteed value.

ii) Impedance value differs the guaranteed value by +/-10% or more.

iii) Winding temperature rise exceeds the specified value.

iv) Transformer fails on any High voltage tests.

v) Transformer is proved to have been manufactured not in accordance with the agreed specification.

The PURCHASER reserves the right to retain the rejected transformer and take it in to service until the VENDOR replaces, at no extra cost to PURCHASER, the defective transformer by a new acceptable transformer.

Alternatively, VENDOR shall repair or replace the transformer within a reasonable period to the PURCHASER's satisfaction at no extra cost to the PURCHASER.

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24.17 Employer's Specification for UAT and SAT

Sl. No.	Description	Particulars	Specification	
1	General			
1.1	Application/Designation		Unit Auxiliary Transformer	Station Auxiliary Transformer
1.2	Quantity required		Refer SLD	
1.3	Installation (Indoor/Outdoor)		Indoor	
1.4	Losses		As per ECBC	
2	Ratings			
2.1	Rating	KVA	4000	2500
2.2	Number of phases & Frequency		3 Ph & 50 HZ ±5%	
2.3	Type of cooling (AN/AF)		AN (Dry Type)	
2.4	No load voltage			
i)	HV	V	13800	11000
ii)	LV	V	433	433
2.5	Vector Group		Dyn11	
i)	Percentage Impedance at principal tapping without tolerance	%	Refer SLD	Refer SLD
ii)	Tolerance on percentage impedance		(No negative tolerance)	(No negative tolerance)
3	Winding			
3.1	Material of conductor (LV/HV)		Copper	
3.2	Class of insulation (LV/HV)		H	
3.3	Method of connection-HV		Delta	
3.4	Method of connection-LV		Star	
4	System Voltage			
4.1	Nominal system voltage HV	V	13800	11000
4.2	Nominal system voltage LV	V	415	415
4.3	Highest system voltage HV	V	17500	12000
4.4	Highest system voltage LV	V	450	450
4.5	Fault Level on HV side	kA	120	25
4.6	Fault Level on LV side	kA	50	50
5	Neutral Earthing			
5.1	System Neutral (A – Effectively earthed; B – Resonant; C – Non effectively earthed; D – Isolated			

Sl. No.	Description	Particulars	Specification	
i)	HV		D	D
ii)	LV		A	A
5.2	Transformer Neutral (A – Effectively earthed; B – Resonant; C – Non effectively earthed; D – Isolated)			
i)	HV		D	D
ii)	LV		A	A
6	Insulation Withstand			
6.1	Impulse (1.2/50 microsec/wave)			
i)	HV		125 kV	
ii)	LV			
6.2	Power Frequency			
i)	HV	kV	50 kV	28 kV
ii)	LV	kV	3 kV	3 kV
6.3	Noise at distance of 1.0 meter	db		
7	Temperature Rise			
7.1	Reference Ambient	°C	50 °C	
i)	Winding temp rise by resistance	°C	Limited to 90 °C	
ii)	WTI – Alarm/ Trip at ambient		°C / °C	
8	Tap Changing Links			
8.1	Type of tap changer		OCTC	
8.2	Tappings on windings	HV/LV	HV	
8.3	Total tapping range		+ 5%	
8.4	Steps	%	In steps of 2.5%	
9	Earthing Terminal			
	Material of Conductor		GI / and it shall comply local statutory requirement	
i)	Size of conductor		As std.	
ii)	Whether cable box to be provided for connecting the cables between neutral and external earth pits	Yes/ No	No	
10	Painting			
10.1	Paint Type			
	Paint Shade:		RAL 7035	

Sl. No.	Description	Particulars	Specification	
10.2	(i) External			
	(ii) Internal			
11	HV Cable Box- Cable Entry (Top/Bottom) and cable size		IPBD (Top Entry)	XLPE Cable (Bottom Entry)
12	LV termination arrangement (Bus duct/ cable box)		Busduct / Cable box	Busduct / Cable box
12.1	If cable box - cable entry (Top/ bottom) –and cable size?		As per layout requirement	As per layout requirement
12.2	If Bus duct- entry type (Top/side)		As per layout requirement	As per layout requirement
13	Neutral CTs			
13.1	Quantity		To be provided	
13.2	Ratio		Refer SLD	
13.3	VA Burden			
13.4	Accuracy Class		5P20 / PS	
13.5	Knee point voltage			
13.6	Magnetizing current at knee-point voltage			
14	Climatic, Environmental and Fire behaviour classes			
14.1	Condition			
i)	•		C2	
ii)	•		E2	

Sl. No.	Description	Particulars	Specification
iii)	•		F1
15	If ECBC norms are applicable, maximum total losses at		
15.1	50% load in Watts		
15.2	10% load in Watts		
16	Neutral rating as % of phase rating	%	100
17	Evaluation & Penalty		
17.1	Formula for evaluation of Bids		Evaluated price + (A x guaranteed no-load loss in kW) + (B x guaranteed load loss in KW) + (C x guaranteed cooler loss in kW)
17.2	Rates of penalty for exceeding the guaranteed losses		Refer Bid evaluation, Section -C2
i)	No load loss		
ii)	Load Loss		
iii)	Aux.loss		

24.18 Employer's Specification for ET and Pothead Yard AT

Sl. No.	Description	Particular	Specifications	
1	General			
2.1	Application/Designation		Potheadyard Auxiliary Transformer	Excitation Transformer
2.2	Quantity required		Refer SLD	
2.3	Installation (Indoor/Outdoor)		Indoor	
2.4	Losses		As per ECBC	
2	Ratings			
2.1	Rating	KVA	200	1000
2.2	Number of phases & Frequency		3 Ph & 50 HZ ±5%	
2.3	Type of cooling (AN/AF)		AN (Dry Type)	
2.4	No load voltage			
i)	HV	V	11000	13800
ii)	LV	V	433	433
2.5	Vector Group		Dyn11	
i)	Percentage Impedance at principal tapping without tolerance	%	Refer SLD (No negative tolerance)	Refer SLD (No negative tolerance)
ii)	Tolerance on percentage impedance			
3	Winding			
3.1	Material of conductor (LV/HV)		Copper	
3.2	Class of insulation (LV/HV)		H	
3.3	Method of connection- HV		Delta	
3.4	Method of connection- LV		Star	
4	System Voltage			
4.1	Nominal system voltage HV	V	11000	13800
4.2	Nominal system voltage LV	V	415	415
4.3	Highest system voltage HV	V	12000	17500
4.4	Highest system voltage LV	V	450	450
4.5	Fault Level on HV side	kA	25	120
4.6	Fault Level on LV side	kA	50	50
5	Neutral Earthing			
5.1	System Neutral (A – Effectively earthed; B – Resonant; C – Non effectively earthed; D - Isolated			
i)	HV		D	D

Sl. No.	Description	Particular	Specifications	
ii)	LV		A	A
5.2	Transformer Neutral (A – Effectively earthed; B – Resonant; C – Non effectively earthed; D – Isolated)			
i)	HV		D	D
ii)	LV		A	A
6	Insulation Withstand			
6.1	Impulse			
i)	Impulse (1.2/50 microsec/wave)	HV	75 kV	95 kV
ii)	Impulse (1.2/50 microsec/wave)	LV		
6.2	Power Frequency			
i)	HV	kV	28 kV	38 kV
ii)	LV	kV	3 kV	3 kV
6.3	Noise at distance of 1.0 meter	db		
7	Temperature Rise			
7.1	Reference Ambient	°C	50 °C	
7.2	Winding temp rise by resistance	°C	Limited to 90 °C	
7.3	WTI – Alarm/ Trip at ambient		°C / °C	
8	Tap Changing Links			
8.1	Type of tap changer		OCTC	
8.2	Tappings on windings	HV/LV	HV	
8.3	Total tapping range		+ 5%	
8.4	Steps	%	In steps of 2.5%	
9	Earthing Terminal			
9.1	Material of Conductor		GI / and it shall comply local statutory requirement	
9.2	Size of conductor		As std.	
9.3	Whether cable box to be provided for connecting the cables between neutral and external earth pits	Yes/ No	No	
10	Painting			
10.1	Paint Type			
10.2	Paint Shade:		RAL 7035	
i)	(a) External			
ii)	(b) Internal			
11	HV Cable Box- Cable Entry (Top/Bottom) and cable size		XLPE Cable (Bottom Entry)	IPBD (Top Entry)
12	LV termination arrangement (Bus duct/ cable box)		Busduct / Cable box	Busduct / Cable box

Sl. No.	Description	Particular	Specifications	
12.1	If cable box - cable entry (Top/ bottom) –and cable size?		As per layout requirement	As per layout requirement
12.2	If Bus duct- entry type (Top/side)		As per layout requirement	As per layout requirement
13	Neutral CTs			
13.1	Quantity		To be provided	
13.2	Ratio		Refer SLD	
13.3	VA Burden			
13.4	Accuracy Class		5P20 / PS	
13.5	Knee point voltage			
13.6	Magnetizing current at knee-point voltage			
14	Climatic, Environmental and Fire behaviours classes			
14.1	Climatic class		C2	
14.2	Environmental class		E2	
14.3	Fire behaviour class		F1	
15	If ECBC norms are applicable, maximum total losses at			
15.1	50% load in Watts			
15.2	100% load in Watts			
16	Neutral rating as % of phase rating	%	100	
17	Evaluation & Penalty			
17.1	Formula for evaluation of Bids		Evaluated price + (A x guaranteed no-load loss in kW) + (B x guaranteed load loss in KW) + (C x guaranteed cooler loss in kW)	
17.2	Rates of penalty for exceeding the guaranteed losses		Refer Bid evaluation, Section -C2	
i)	No load loss			
ii)	Load Loss			
iii)	Aux.loss			

DATA SHEET – A3

Sl.No.	Description	Unit	Technical Requirement	
1	General			
1.1	Application/Designation		33kV Service Transformer	
1.2	Quantity required		Chaplangchhu Intake-1 No, Tailrace Outfall, -1 No,	BFV area-1 No, Surge Shaft-1 No, Dam-2 Nos,
1.3	Installation (Indoor/Outdoor)		Outdoor	
1.4	Losses		As per ECBC	
2	Ratings			
2.1	Rating	KVA	200	500
2.2	Number of phases & Frequency		3 Ph & 50 HZ ±5%	
2.3	Type of cooling		ONAN	
2.4	No load voltage HV	V	33000	33000
2.5	LV	V	433	433
2.6	Vector Group		Dyn11	
2.7	(a) Percentage Impedance at principal tapping without tolerance (b) Tolerance on percentage impedance	%	Refer SLD (No negative tolerance)	Refer SLD (No negative tolerance)
3	Winding			
3.1	Material of conductor (LV/HV)		Copper	
3.2	Class of insulation (LV/HV)		H	
3.3	Method of connection- HV		Delta	
3.4	Method of connection- LV		Star	
4	System Voltage			
4.1	Nominal system voltage HV	V	33000	33000
4.2	LV	V	415	415
4.3	Highest system voltage HV	V	36000	36000
4.4	LV	V	450	450
4.5	Fault Level on HV side	kA	31.5	31.5
4.6	Fault Level on LV side	kA	50	50
5	Neutral Earthing			
5.1	System Neutral (A – Effectively earthed; B – Resonant; C – Non effectively earthed; D - Isolated			
i)	HV		D	D
ii)	LV		A	A

Sl.No.	Description	Unit	Technical Requirement	
5.2	Transformer Neutral (A – Effectively earthed; B – Resonant; C – Non effectively earthed; D – Isolated)			
i)	HV		D	D
ii)	LV		A	A
6	Insulation Withstand			
6.1	Impulse (1.2/50 microsec/wave)			
i)	HV		170 kV	170 kV
ii)	LV	LV		
6.2	Power Frequency			
i)	HV	kV	70 kV	70 kV
ii)	LV	kV	3 kV	3 kV
6.3	Noise at distance of 1.0 meter	db		
7	Temperature Rise			
7.1	Reference Ambient	°C	50 °C	
7.2	i) Winding temp rise by resistance	°C	Limited to 90 °C	
	ii) WTI – Alarm/ Trip at ambient		°C / °C	
8	Tap changing links			
8.1	Type of tap changer		OCTC	
8.2	Tappings on windings	HV/ LV	HV	
8.3	Total tapping range		+ 5%	
8.4	Steps	%	In steps of 2.5%	
9	Earthing Terminal			
9.1	Material of Conductor		GI / and it shall comply local statutory requirement	
9.2	Size of conductor		As std.	
9.3	Whether cable box to be provided for connecting the cables between neutral and external earth pits	Yes/ No	No	
10	Painting			
10.1	Paint Type			
10.2	Paint Shade:		RAL 7035	
	i) External			
	ii) Internal			
11	HV Cable Box- Cable Entry (Top/Bottom) and cable size		Refer SLD	Refer SLD
12	LV termination arrangement (Bus duct/ cable box)		Refer SLD	Refer SLD
12.1	If cable box - cable entry (Top/ bottom) –and cable size?		As per layout requirement	As per layout requirement
12.2	If Bus duct- entry type (Top/side)		As per layout requirement	As per layout requirement
13	Neutral CTs			

Sl.No.	Description	Unit	Technical Requirement
13.1	Quantity		To be provided
13.2	Ratio		Refer SLD
13.3	VA Burden		
13.4	Accuracy Class		5P20 / PS
13.5	Knee point voltage		
13.6	Magnetizing current at knee-point voltage		
14	Climatic, Environmental and Fire behaviours classes		
i)	Climatic class		C2
ii)	Environmental class		E2
iii)	Fire behaviour class		F1
15	If ECBC norms are applicable, maximum total losses at 50% load in Watts 100% load in Watts		
16	Neutral rating as % of phase rating	%	100
17	Evaluation & Penalty		
17.01	Formula for evaluation of Bids		Evaluated price + (A x guaranteed no-load loss in kW) + (B x guaranteed load loss in KW) + (C x guaranteed cooler loss in kW)
17.02	Rates of penalty for exceeding the guaranteed losses i) No load loss ii) Load Loss iii) Aux.loss		Refer Bid evaluation, Section -C2

DATA SHEET – A4

Sl. No	Description	Particular	Specifications
1	General		
1.1	Application/Designation		Station Auxiliary Transformer
1.2	Quantity		2 Nos.
1.3	Installation	Indoor/ Outdoor	Outdoor type
1.4	Type	2-Winding / 3-Winding	2 – Winding
1.5	Three Phase / Single Phase Unit		3-phase
2	Rating of each Winding		
2.1	HV Winding	MVA	(This rating to be verified based on Load List)
2.2	LV Winding	MVA	(This rating to be verified based on Load List)
2.3	Type of Cooling		ONAN
2.4	Efficiency		>98.5%
3	Ratings		
3.1	No load voltage		
i)	LV Winding	kV	11
ii)	HV Winding	kV	33
4	Frequency	Hz	50
5	Rating for each type of cooling		100% ONAN
6	Percentage impedance	%	7* (with IS tolerance)
7	Core		
7.1	Over fluxing		
i)			1.10 - CONTINUOUS
ii)			1.25 - 1 MINUTE
iii)			1.40 - 5 SEC
iv)			1.50 - 2 SEC
7.2	Maximum Flux Density		

Sl. No	Description	Particular	Specifications
i)			AT RATED VOLTAGE 1.7 Wb/m2
ii)			AT 110% RATED VOLTAGE 1.9 Wb/m2
7.3	Current Density		
i)			HV 2.5 A/sq. mm
ii)			LV 2.5A/sq. mm
8	Transformer External Short Circuit Withstand Capacity		Transformer shall be designed for bolted Short Circuit (SC) at its terminal (HV or LV) considering only self-percentage Impedance for 3 second thermal rating and dynamic rating as per IEC 60076.
9	Winding Connections		
9.1	Winding Connection (Vector Group)		Dyn11
9.2	Direction of Power Flow		Bi-directional
10	System Data		
10.1	System Voltage		
i)	HV – Nominal / Highest	kV / kV	33 / 36
ii)	LV – Nominal / Highest	kV / kV	11 / 12
iii)	Fault Level		
iv)	LV system	kA	Refer SLD
v)	HV system	kA	Refer SLD
vi)	System Neutral Earthing		
vii)	Effectively Resonant Non-effectively Isolated	LV	Effectively (Solidly earthed)
		HV	Unearthed
11	Winding Insulation		
i)	Uniformly insulated	LV	Uniformly insulated
ii)	Non-uniformly insulated	HV	Uniformly insulated
12	Transformer Neutral		
12.1	Type of earthing		
i)	Directly / Solidly earthed	LV	Solidly earthed (Star side)

Sl. No	Description	Particular	Specifications
	Non-effectively Isolated / Unearthed	HV	Unearthed (Delta side)
13	Winding Insulation Test Voltages		
13.1	Lightning Impulse voltage withstand +ve/-ve (1.2/50µs Wave)		
13.2	LV / HV	kV (Peak)	75 / 170
13.3	Switching Impulse voltage withstand +ve/-ve (250 / 2500µs Wave) for HV	kV(Peak)	-
13.4	Power frequency voltage withstand		
13.5	LV and HV (primary and secondary)	kV (rms)	28 / 70
14	Temperature Rise		
14.1	Ambient temperature		REFER SECTION-B (PROJECT INFORMATION)
i)	Maximum ambient air		
ii)	Maximum daily average air		
iii)	Maximum yearly average air		
iv)	Cooling water (Maximum)		
v)	Temperature rise of top oil by thermometer	°C	55
vi)	Maximum temperature rise of windings by resistance	°C	60
15	Tapping		
15.1	Tapping on windings		HV
15.2	Whether on load / off-circuit		Off- load
15.3	Tapping range	%	+10% to -10%
15.4	Tapping step	%	1.25
15.5	Category of voltage variation (CFVV / VFVV / CbVV)		CFVV
15.6	Capacity	Full / Reduced	FULL
16	Tap Changer (OLTC/OCTC)		OCTC
16.1	Control		Manual control at Local
16.2	Control cubicle	By BIDDER / PURCHASER	BY BIDDER
16.3	Voltage class of OLTC	kV	**
16.4	Current rating of OLTC	A	**
17	Terminal Bushings		
	Data		

Sl. No	Description	Particular	Specifications
i) Particulars	LV Line End	LV Line End (Neutral)	HV Line End
a) Rated Voltage class – kV	12	12	36
b) Rated current class – A	BY BIDDER	BY BIDDER	BY BIDDER
c) Impulse (1.2/50µsec Wave withstand) – kV (Peak)	75	95	170
d) One minute power frequency withstands (Dry & Wet) kV(rms)	30	28	77
e) Protected creepage distance – mm	BY BIDDER	BY BIDDER	BY BIDDER
18	Bushing Current Transformer (BCT)		
18.1	Data		
i) Application		BCT Core No.	B C T Particulars
a) HV line side for restricted earth fault protection (star side)		As per the requirement.	
b) For winding temperature measurement (star side)			
c) HV neutral side for restricted earth fault protection (star side)			
d) HV neutral side for standby E/F protection (star side)			
19	Terminal Connections		
19.1	Terminal connections – A/B/C (See Notes)		
i)	LV Wdg (primary) Line end		XLPE Cable
ii)	HV Wdg (secondary) Line end		XLPE Cable
iii)	HV Wdg (secondary) Neutral end		Two (2) nos. 65x10mm Copper FLAT. Neutral point connected to FLAT supported on insulators on tank body from bushing to ground level.
20	Earthing Conductor		
20.1	Material		GS / Copper (as per EB requirement)
20.2	Size		Two (2) nos. 65x10mm

Sl. No	Description	Particular	Specifications
21	Nitrogen Injection Type Fire Protection System (NIFPS)		Not Required
22	Miscellaneous		
22.1	Parameters		
i)	Impulse test		
ii)	Full wave	Required / Not Required	Not Required
iii)	Chopped wave	Required / Not Required	Not Required
iv)	Type test	Required / Not Required	Required for 1 Transformer
v)	Special test	Required / Not required	Required for 1 Transformer
vi)	Buchholz Relay		Double float type with potential free alarm and trip contacts
vii)	Winding temperature indicator and Oil Temperature indicator for Local & Remote	Required / Not required	Required
viii)	Oil level gauge		Prismatic
ix)	Type	Magnetic / Prismatic	Both
x)	Dial size		150mm dia
xi)	Transducer for Top oil temp.	Required / Not Required	Required
xii)	Transducer for winding temperature and Windings	Required / Not Required	Required for windings
xiii)	Colour shade of final painting	Shade Number	631 of IS 5
xiv)	Bolted joint near base of tank	Required / Not Required	Required
xv)	Skids	Required / Not Required	Required
xvi)	Wheel		
xvii)	Plain / Flanged		Flanged
xviii)	Unidirectional / Bi-directional		Bi-directional
xix)	Additional wheels for stability required	Yes / No	Yes
xx)	Vacuums withstand capability		
xxi)	Main tank with bushings, fittings and accessories		Full vacuum
xxii)	Radiators		Full vacuum
xxiii)	Transformer to be transported:		

Sl. No	Description	Particular	Specifications
	a) Filled with oil		As per project requirement & site condition.
	b) Without oil with inert gas, gas cylinder, reducer connection, pressure gauge		As per project requirement & site condition.
xxiv)	Additional drain valve to be located away from the transformer to operate if there is fire in transformer.		Required.
xxv)	Permissible PPM of insulating oil		PPM IN OIL - ppm < OR = 5 PPM
	NOTES		
	2x50 % Capacity separately mounted radiator bank shall be provided.		
	** Data to be filled by the bidder.		

24.19 Applicable Standards

Sl. No.	Applicable Standards	References
1	Equipment's	
1.1	Dry type transformer	□ IEC 60076-11□ IS 2026-11
1.2	Specification for painting and colour shade	□ IS 5
1.3	Fittings and Accessories	□ IS 3639
1.4	Loading guide of dry type transformer	□ IEC 60076-12 □ IS 2026-12
1.5	Degree of protection	□ IS/IEC:60529
1.6	Electrical insulation classified by thermal stability	□ IS 1271
1.7	Insulated Bushing for alternating voltages above 1000 Volts	□ IS/IEC 60137 □ IS 3347 □ IS 8603
1.8	Bushing for alternating voltages below 1000 Volts	□ IS 7421 □ IS 3347
1.9	Dimension for porcelain and transformer bushings	□ IS 3347
1.10	Low voltage switchgear and control gear	□ IS 13947
1.11	Sound level	□ IEC 60076-10 □ IEC 2026-10
1.12	Energy conservation building code (ECBC)	□ ECBC

24.20 Mandatory Spares

Sl. No	Equipment	Quantity and Particular
1	**MV/LV Transformer**	
1.1	**Station Auxiliary Transformers (33/11kV)**	
i)	HV Bushing	3 Nos. of each type & rating
ii)	LV Bushing	3 Nos. of each type & rating
iii)	Neutral bushing	3 Nos. of each type & rating
iv)	Buchholz relay complete (main tank)	1 No. of each type & rating
v)	Local Winding temperature indicator	1 No. of each type & rating
vi)	Remote winding temperature indicator with sensing device and matching unit	1 No. of each type & rating
vii)	Oil temperature indicator	1 No. of each type & rating
viii)	Pressure relief device	1 No. of each type & rating
ix)	Magnetic oil level gauge	1 No. of each type & rating
x)	Cooler Fan with motor	1 No. of each type & rating
xi)	Set of Valves	1 No. of each size and type
xii)	Set of starters, contactors, relays and switches for electrical control panel	1 No. of each type & rating
xiii)	Remote tap position indicator	1 No. of each type & rating
xiv)	Oil flow indicator	1 set of each type & rating
xv)	Terminal connector	1 set of each type & rating
xvi)	Gaskets for Bushings, flanges, manholes	1 set of each type & rating
xvii)	Insulating oil	10% of quantity of oil
2	**LT Transformers & Accessories**	
2.1	**Unit Aux Transformer 13.8/0.433 kV**	
i)	HV Bushing / Insulator	2 sets of each type and rating
ii)	LV Bushing / Insulator	2 sets of each type and rating
iii)	WTI with sensing device	2 sets
iv)	OTI with sensing device (if applicable)	2 sets
v)	Tap Changer contacts	2 sets
vi)	Door switch	2 sets
vii)	Current transformer used	2 sets of each type and rating
viii)	Buchholz relay (if applicable)	1 No Each type
ix)	Explosion vent diaphragm (if applicable)	1 No Each type
x)	Silica gel Container (if applicable)	1 No Each type
3	**Station Service Transformer 11/0.433 kV**	
3.1	**Transformer details**	
i)	HV Bushing / Insulator	2 sets of each type and rating
ii)	LV Bushing / Insulator	2 sets of each type and rating
iii)	WTI with sensing device	2 sets
iv)	OTI with sensing device (if applicable)	2 sets
v)	Tap Changer contacts	2 sets
vi)	Door switch	2 sets
vii)	Current transformer used	sets of each type and rating
viii)	Buchholz relay (if applicable)	1 No Each type
ix)	Explosion vent diaphragm (if applicable)	1 No Each type
x)	Silica gel Container (if applicable)	1 No Each type

CHAPTER 25: LIGHTING SYSTEM

25.1 Scope of Work

i) This Specification covers the requirements of sizing, design, engineering, material selection, constructional features, manufacture, inspection and testing at the VENDOR'S or his SUB-VENDOR'S Works, delivery to Site including transit insurance, installation, testing & commissioning and performance testing of Indoor and Outdoor lighting system equipment. The indoor equipment include lighting distribution boards, panels (Single phase/Three phase), switches, power receptacle units, lighting wires, junction box, conduits and its accessories, ceiling fans etc, The outdoor equipment include outdoor lighting distribution boards/panels, lighting poles (Street light/Flood light/High mast), LT power cables, etc.

ii) Lighting system shall be provided for the entire power plant covering the powerhouse, outdoor yard, DG house, roads, GIS, Transformer area, pothead yard area & system / structures of power plant including valve house, upper/lower reservoir control buildings, etc. (outdoor lighting distance coverage)

iii) The power plant illumination will comprise of interior and exterior illumination as appropriate for the entire powerhouse area, transformer yard, pothead area, and intakes on both reservoir areas and other important areas. A separate emergency lighting system, fed from the station battery system, will be provided for essential locations. The illumination levels will be generally as per applicable local practices.

iv) Illumination of the strategic locations by High mast light fittings, luminaires such as HPSV lamps, fluorescent tubes, Acid proof fittings in battery room, Explosion proof light fittings in D.G. set room Incandescent lamps (for emergency lighting from DC Batteries) etc. shall be suitably provided. All the luminaries of LED type.

25.2 Codes & Standards

i) The items of supply shall conform to the latest applicable electrical rules, all currently applicable standards codes of practice indicated in Data Sheet A2, regulations and safety codes of the locality where the equipment are to be installed. In case of conflict between these standards and specification, the more stringent of the two shall govern. Nothing in this specification shall be construed to relieve the CONTRACTOR of his responsibility. Where no standards are available, the supply items shall be backed by test result, shall be of good quality and workmanship and any supply items which are bought out by the VENDOR shall be procured from approved manufacturers acceptable to the PURCHASER/ENGINEER.

ii) The codes and standards mentioned in the various specifications and requirements specified in the enquiry document shall be latest as on the day of execution of the works unless otherwise specified. The revisions in the relevant codes and standards after the date of award of contract shall be informed by the Contractor to the Consultant/ Owner within 30 days of the issue of such revision of the code/ standard. Consultant/ Owner may approve use of the earlier code/ standard if the revisions do not materially affect the Statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed.

iii) The CONTRACTOR shall ensure that instruments and gauges to be used for testing and inspection of critical parameters as identified in the specification have valid calibration and the accuracy can be traced to National/International standards, as applicable.

25.3 Categories of Lighting

The lighting system shall comprise the following categories:

i) Normal 240V Single phase AC lighting system

ii) Normal / Emergency AC lighting system

iii) Emergency 220V DC lighting system

25.4 Normal 240V AC lighting system

In this system, the lighting circuits shall be fed by the 3 phase, 4 wire normal AC supply available from the normal lighting distribution boards. All the lighting fixtures connected to this system shall be available as long as supply is available from normal source. The lighting distribution board shall receive supply from plant 415V AC switchboard.

25.5 Normal / Emergency AC lighting system

Certain lighting fixtures considered essential shall be connected to this system. In this system the lighting circuits shall be fed from lighting distribution board connected to 415V Normal/Emergency Switchgear. The lighting fixtures connected to this system shall be available whenever normal supply is available in the plant and also whenever DG set supplies power to N/E switchgear when normal supply fails.

25.6 Emergency DC lighting system

i) During station emergency involving total AC failure, DC lighting fixtures shall be provided for movement of personal in power house at strategic locations, viz., near entrance, staircase landings etc., and for lighting the control room.

ii) These fixtures shall be connected to lighting panels supplied from 220V DC battery. These lighting fixtures shall be normally `Off' and shall automatically get switched on the moment AC power supply fails. When power supply is restored they shall be switched off automatically.

iii) UPS/Inverter lighting shall also be adopted.

- **Testing facility of emergency lights to be provided**
- **The area-wise distribution of lighting fixtures connected to the systems discussed above shall be as follows:**

Sl. No.	Area /Building	Percentage wise distribution of Lighting	
		Normal	220V DC & UPS
1	Powerhouse, control/switchgear, GIS, Transformer room	100%	20%*
2	Outdoor yard, DG house	100%	20%*
3	Roads & peripheral lighting	100%	-

25.7 Lighting supply Distribution system

25.7.1 Normal AC systems

i) For these systems, the distribution shall be by 415V, 3 phase, 4 wire, 50Hz supply with effectively earthed neutral. This supply shall be derived from 415V, 3 phase, 4 wire, 50Hz switchgear. LDBs shall be provided with number of outgoing circuits controlled by MCCB depending on fault levels to feed the lighting panels.

ii) The indoor lighting panels shall be provided with one incoming 4P MCB & shall have per phase isolations with DP ELCB on each phase as sub- incomer. The outgoings shall be SP MCBs. The panel shall conform to IS-8623.

iii) The control of all outdoor area lighting shall be done automatically through multi-programmable timer units. Also, manual switching 'on' and 'off' facility shall be provided.

iv) Exit signages shall be illumination type and shall be provided with AC/DC fixtures with built in Battery (3 hours backup). These signages shall be normally fed from AC supply.

25.7.2 DC Lighting system

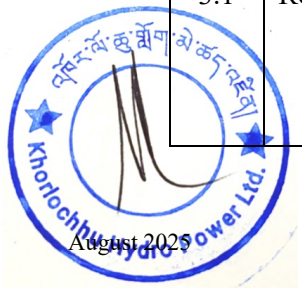
Emergency DC lighting supply distribution shall be on 220V DC, 2 wire unearthed system. This power supply shall be obtained from plant 220V DC switchboard. DC lighting panel shall be provided for distribution of lighting supply. DC lighting panel shall have one (1) incomer controlled by double pole DC switch, fuses and a DC contactor and shall have number of outgoing circuits controlled by MCB. Upon failure of the normal-cum-emergency AC supply connected to this panel, the under voltage relay provided inside this panel drops off. Its normally closed auxiliary contact shall energise the contactor to switch on the emergency DC supply. The system shall not switch off or reset automatically upon restoration of normal AC supply but only after manually reset. The panel construction shall be similar to normal lighting panels.

25.8 Illumination levels and choice of lighting fixtures

The area-wise distribution of average illumination levels and type of luminaires shall be as given below.

Sl. No	Area/ Structure	Average Lux Level	Type of Fixture	Type of Luminaire
1	**Powerhouse**			
1.1	Generator Hall / Maintenance area	200	Industrial LED High Bay / Medium bay fixture with Die Cast Aluminium housing having IP 65	70 W / 110W / 140W LED
1.2	Switchgear room / Battery Room/ GIS Hall	250	Industrial LED light fixture with polycarbonate housing aluminium gear tray and opal cover of polycarbonate suitable for surface mounting. Minimum degree of protection IP 66.	2 x 20 W LED
1.3	Control and Relay room	500	Recessed mounted LED luminarie with CRCA housing, integral driver and anti glare diffuser.	36W LED
1.4	Stores	200	Industrial LED light fixture with polycarbonate housing aluminium gear tray and opal cover of polycarbonate suitable for surface mounting. Minimum degree of protection IP 66.	2 x 20 W LED
1.5	DG set	100	Industrial LED Street light fixture with extruded aluminium housing as heat sink, heat resistant toughened glass, control gear	18 W LED

			compartment. Degree of protection IP 66.	
1.6	Indoor Transformer Room	150	Industrial LED Street light fixture with extruded aluminium housing as heat sink, heat resistant toughened glass, control gear compartment. Degree of protection IP 66.	18 W LED / 72 W LED
1.7	Toilet / Corridor	150	Industrial LED light fixture with round panel with body made from die cast aluminium and CRCA covering, powder coated suitable for surface mounting. Minimum degree of protection IP 20.	18 W LED
1.8	Main Access Tunnel(MAT)	150	Industrial LED Street light fixture with extruded aluminium housing as heat sink, heat resistant toughened glass, control gear compartment. Degree of protection IP 66.	18W LED
2	**Outdoor yard**			
2.1	General	20	Industrial LED flood light fixture with extruded aluminium housing as heat sink, heat resistant toughened glass, control gear compartment. Degree of protection IP 65.	140W LED
			Industrial LED Street light fixture with extruded aluminium housing as heat sink, heat resistant toughened glass, control gear compartment. Degree of protection IP 66.	72 W LED
2.2	Switchyard outdoor portion	50	Industrial LED flood light fixture with extruded aluminium housing as heat sink, heat resistant toughened glass, control gear compartment. Degree of protection IP 65.	140W LED
3	**Road Lighting**			
3.1	Roads	20	Industrial LED Street light fixture with extruded aluminium housing as heat sink, heat resistant toughened glass, control gear	72 W LED



			compartment. Degree of protection IP 66.	
3.2	Building periphery lighting	15	Industrial LED Street light fixture with extruded aluminium housing as heat sink, heat resistant toughened glass, control gear compartment. Degree of protection IP 66.	18 W LED
3.3	Site boundary / periphery	10	Industrial LED Street light fixture with extruded aluminium housing as heat sink, heat resistant toughened glass, control gear compartment. Degree of protection IP 66.	120 W LED
4	**DC Light Fitting**			
4.1	Control room Building	-	Industrial LED light fixture with polycarbonate housing aluminium gear tray and opal cover of polycarbonate suitable for surface mounting. Minimum degree of protection IP 66.	36W LED
5	**BVC and Surge shaft**			
5.1	Access Tunnel	200	Industrial LED Street light fixture with extruded aluminium housing as heat sink, heat resistant toughened glass, control gear compartment. Degree of protection IP 65	70 W / 110W / 140W LED
5.2	Chamber	150	Industrial LED Street light fixture with extruded aluminium housing as heat sink, heat resistant toughened glass, control gear compartment. Degree of protection IP 67.	18W LED
5.3	Outdoor	20	Industrial LED Street light fixture with extruded aluminium housing as heat sink, heat resistant toughened glass, control gear compartment. Degree of protection IP 66.	
5.4	Surge shaft	20	Industrial LED Street light fixture with extruded aluminium housing as heat sink, heat resistant toughened glass, control gear	72 W LED

			compartment. Degree of protection IP 66	
5.5	IPS 1 and IPS 2	150	Industrial LED Street light fixture with extruded aluminium housing as heat sink, heat resistant toughened glass, control gear compartment. Degree of protection IP 67.	18W LED
6	**DAM Complex**			
6.1	Control Room	100	Industrial LED Street light fixture with extruded aluminium housing as heat sink, heat resistant toughened glass, control gear compartment. Degree of protection IP 66.	18 W LED
6.2	Outdoor	50	Industrial LED flood light fixture with extruded aluminium housing as heat sink, heat resistant toughened glass, control gear compartment. Degree of protection IP 66.	140W LED
6.3	SFT	150	Industrial LED Street light fixture with extruded aluminium housing as heat sink, heat resistant toughened glass, control gear compartment. Degree of protection IP 67.	18W LED
7	**Chaplangchhu Intake and drop shaft**			
7.1	Outdoor	50	Industrial LED flood light fixture with extruded aluminium housing as heat sink, heat resistant toughened glass, control gear compartment. Degree of protection IP 66.	140W LED

The illumination levels for areas, which are not specifically covered above, shall be decided based on illumination levels indicated for similar areas or in relevant standards.

The above list is tentative. Final model/type will be decided during detailed engineering.

25.9 Lighting system design

The Contractor shall furnish lighting design calculations by Dialux software and detailed lighting layout drawings for purchaser's approval. The lighting system design shall comply with the acceptable norms and the best engineering practices. The system design shall consider principles of lighting specified in following paragraphs. The lighting layout shall be designed to provide uniform illumination with minimum glare. The layout design shall meet all the statutory requirement, local rules etc.

25.10 Indoor lighting

The illumination level for various areas in the plant is indicated in the Table above. Following factors shall be considered while arriving at the utilisation factor to determine the number of fixtures for each area/building in the plant.

i) Maintenance factor

a) Control room : 0.8

b) All other indoor areas : 0.7

c) Outdoor areas : 0.6

ii) Reflection factor for wall and ceiling depend on texture

a) White & very light colour : 0.7

b) Light colours : 0.5

c) Middle tinits : 0.3

d) Dark colours : 0.1

iii) The value of the ratio of spacing (S) to mounting height (H) shall be commensurate with the type of fittings selected, uniformity of illumination. The suspension height for suspended fixtures shall not exceed 1metre.

iv) Uniformity ratio shall be considered as per NLC 2010

v) Sensor lighting shall be used wherever necessary. However, will be decided during detailed engineering.

25.11 Roadway lighting

i) Lighting design shall consider a maintenance factor of 0.6 for average conditions.

ii) Ratio of minimum to average illumination shall not be less than 0.3. The road lighting layout shall consider the width of the road to decide whether the lighting poles shall be located on one side, on either side or in the central reserve.

iii) The mounting height of the luminaires shall be generally minimum 9 metres.

iv) The control gear for lights shall be of non-integral type i.e.; the control gear of the light fixture shall be mounted at about 0.54 above the ground level.

25.12 Selection of lighting fixtures and accessories

The type of LED luminaries and accessories like switches, receptacles etc., shall be selected based on the plant area in which they are intended to be used.

25.13 LED lighting fixtures

i) All luminaries shall be complete with accessories like lamps, ballasts, Driver, power factor improvement capacitors, starters etc.

ii) Necessary Active Power Filters for the LED fixtures to be considered.

iii) All LED luminaries shall be provided with toughened glass and shall have thickness of sufficient strength and high efficiency prismatic diffuser under the LED chamber to protect the LED and luminaries.

iv) Suitable reflector / lenses may also be provided to increase the illumination uniformity and distribution for LED.

v) The fixture shall be designed so as to have lumen maintenance of at least 70% at the end of 50,000 hours (L70) at design temperature of 35 degree C.

vi) Adequate heat sink with proper thermal management shall be provided.

vii) Minimum view angle of the LED shall not be less than 120 degree.

viii) Power factor of complete fitting shall be more than 0.95 at full load 240V and THD<8%.

ix) The LED luminaries shall be free of glare. Colour rendering index (CRI) shall be ≥ 75. System luminous efficacy for indoor area shall be ≥80.

x) The luminaries should be an inbuilt surge protection of not less than 4 KV to prevent in damage to the driver in case of sudden voltage surge.

xi) LED fixture shall be selected suitable such that if there is any repair/damage, it should be easily replaceable of the component of LED fixture only instead of complete fixture.

xii) Lumen maintenance report as per LM 80 guidelines shall be produced for the LEDs used. The test report shall contain description of the source tested/Ambient Condition (Airflow, Temperature etc.)/Electrical Condition/Lumen Maintenance Data/Observation of failure (Lumen depreciation monitored every 1000 hours)/LED Monitoring Interval/Chromaticity shift over time. The LED chips shall have system luminous efficacy of 100 lm/W or more and LED fixture shall have system efficacy of 70 lm/W or more.

xiii) Bidder shall submit LM 79 (Electrical & Solid-State measurement of solid state lighting products/fixtures). The test report shall contain Total lumen output of the fixture/luminaire intensity distribution/electrical power/luminous efficacy/colour characteristic of the fixture i.e. CCT & CRI.

25.14 Switches and receptacles

i) In the plant areas, the lighting circuits shall be controlled directly from the MCBs in the lighting panels. Wherever the lighting panel is not in the same area, separate switches shall be provided. For cabins, rooms etc., separate switches shall be provided for each point. Similarly for entrances, building periphery lighting separate switches shall be provided.

ii) 240V, 50Hz, 3 pin power receptacles (5A and 15A) shall be provided in all building/areas of the plant. Also inside a building, receptacles shall be provided at regular intervals so that any point of the building is not more than 10m with a minimum of 2 nos., in an enclosed area. Inside each cabins at least two receptacles shall be provided. The same shall be indoor / outdoor.

iii) The welding receptacle shall be of 63 A, industrial heavy duty type with 5pin (with earth connection) suitable for 415 V, 3 phase, 50 Hz supply. The receptacle, ELCB switch & fuse shall be housed in a sheet steel enclosure complete with gasket, cable glands etc. The enclosure shall be min. 2 mm. thick galvanized sheet steel and shall conform to the degree of protection IP-55 class. All receptacles shall be provided with matching plug tops. The receptacle and switch shall be interlocked with the plug such that it shall not be possible to remove the plug with the switch in 'ON' position.

iv) The switch boxes, receptacle boxes etc., shall be made up of 18 SWG sheet steel.

25.15 Lighting distribution boards (LDB)

The LDBs shall be provided with voltmeters and ammeters along with selector switches, Supply On' indicating lamps, etc. The LDBs shall be sheet steel enclosed, floor mounted and shall be fully dust and vermin proof, with a degree of protection IP 54 for indoor and IP 55 for outdoor. The lighting distribution boards shall be provided with MCCB for incomer and MCCBs for outgoing feeders arranged in tier formation. Detailed specification of LDB refers in LT switchgear sections.

The lighting transformer housed in LDB shall be dry type, 415/433V (Street lighting LDBs and DBs which are located far from the source PCC/MCC/DB) and 415V / 415 V(Other LDBs), Z=4%, OCTC with +/-10% tap in steps of 2.5%. WTI with alarm and trip contact shall be provided for winding. Each lighting transformer shall be routine tested after housing it in cubicle and type test certificates shall be submitted which shall not be more than 5 years.

Busbars shall be of aluminium alloy of E91E grade. The neutral bus of the main 3 phase, 4 wire distribution board shall be rated for full short circuit rating of main busbar

The distribution of lighting fixtures/receptacles shall be such that the loading on each phase of the LDB is approximately equal.

25.16 Lighting panels (lp) / receptacle panel

The indoor lighting panels shall be provided with one incoming 4P MCB & shall have per phase isolations with DP ELCB on each phase as sub- incomer. The outgoings shall be SP MCBs. The panel shall conform to IS-862.

i) 415V, 20A/32A/63A, FP MCB Isolator

ii) Required no.of 10A/16A/20A, MCB outgoing feeders with neutral links & 20% Spare feeders.

iii) 20A/32A/63A TP contactor with timer, photocell and by pass switch arrangement for outdoor lighting.

iv) It shall be sheet steel enclosed and shall be fully dust and vermin proof, with a degree of protection of IP 54. Outdoor panels shall be weather proof type with IP 55 degree of protection & Rain hood arrangement.

v) The lighting panel's hinged, latched front door shall be provided with key-locking facility and a slotted bakelite sheet inside. Only the ELCBs/MCBs operating knobs shall project out of the bakelite sheet slots for safe operation and neat appearance

25.17 Wiring

i) 1100V grade multi stranded copper conductor, PVC insulated wires laid in GI conduits shall be used for lighting in non-hazardous area. In the hazardous areas cable wiring with 1100V grade multi stranded copper conductor, XLPE insulated, PVC inner sheathed, GI wire armoured and outer sheathed with extruded FRLS PVC compound type ST2 complying with IS: 7098.

ii) Minimum size of wires in case of conduit wiring shall be 2.5Sq.mm in case of lighting and 4Sq.mm in case of receptacle wiring. Minimum cable size in case of cable wiring shall be 4Sq.mm.

iii) Wires of different phases shall be run in separate conduits. However wires of same phase but having different circuit nos. can be run in same conduit. Wires of lighting and power receptacles shall be carried out in separate conduits and on separate circuits. Wires of AC and DC lighting systems shall be carried out in separate conduits.

iv) For Phase, neutral & earthing copper wire / cable shall be used.

v) All cables shall be FRLS type and provided with anti-rodent treatment.

25.18 Lighting circuit design

In an area, the lighting fixtures shall be arranged in different phases/LPs such that even in case one phase goes faulty complete lighting is not affected. In a room the lighting shall be arranged from two phases.

i) The circuit loading on each circuit shall be restricted to 80% of the RCBO/MCB rating.

ii) The voltage drop from LDB and any fixture shall not exceed 3%.

25.19 Lighting poles for street lighting

i) Lighting poles shall be of swaged curved type steel poles as per applicable standards. Lighting pole shall be GI. Minimum height of pole shall be 11 meter from FGL.

ii) The supply of poles shall be complete with fixing bracket/necessary pipe reducer for fixing the fitting and also include the necessary associated pole mounted junction boxes. Junction boxes with hinged door & suitable locking with key arrangement shall be provided at the bottom of each street lighting pole. This box shall contain 6 Amps HRC fuses, neutral links, terminal blocks suitable for loop-in loop-out of at least 3 ½ C, 35 sq mm aluminium cables, ground stud etc. GI conduit shall be embedded in muff for incoming & outgoing cables. Supply to luminaires shall be taken through 1100 V, 3x2.5 sq mm PVC insulated, unarmoured cable with stranded copper conductor.

iii) It shall be ensured earth continuity from the luminaire body to earth grid through pole/looping box. Two numbers of welded earth terminals with bolts shall be provided on the pole.

iv) Decorative lantern luminaires shall be outdoor weather proof type with degree of protection minimum IP 55, cast aluminium epoxy powder coated housing, prismatic heat resistant, toughened glass cover complete with neoprene gaskets, top or side conduit entry and integral mounted control gear box.

25.20 Ceiling fans / wall mounted fans

Ceiling/Wall mounted fans shall be suitable for operation on 240 V, 1 phase, 50 Hz supply and shall be complete with standard mounting accessories such as suspension rods, top and bottom caps etc for ceiling fans and easy accessibility for wall mounted fans. The fans shall be supplied with appropriate speed regulators.

Wall mounted fans shall be provided in all the floors as per working area / monitoring area as identified.

25.21 Earthing

i) Lighting fixtures, receptacles, switches, conduits and junction boxes shall be properly earthed using copper wire of 14 SWG run along the entire length of the conduit between the fixture and the corresponding lighting panel where it will be connected to the station earth.

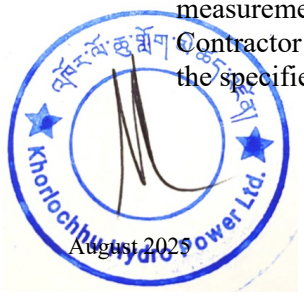
ii) For fixtures in hazardous areas, the third core of each single-phase armoured cable circuit shall be used as earthing conductor.

iii) For outdoor earthing of lighting poles, junction boxes on the poles, 14 SWG Cu wire, shall be run buried in ground at a depth of 600mm and tapped to each lighting pole. The earth conductor shall be connected to the nearby main earthing grid at the first and last poles of each feeder circuit and at some intermediate poles.

25.22 Tests

Acceptance tests & routine tests for the lighting fixtures and accessories covered in this specification shall be carried out.

Following the installation of lighting system, the Contractor shall carry out lux level measurements in all areas. If the lux levels are observed less than the specified levels, the Contractor shall supply and install additional lighting fixtures to improve the lux level to meet the specified values



25.23 Mandatory Spares

Sl. No.	Equipment's	Unit	Qty
1	**Lighting system**		
1.1	Indoor light fixture	Nos. of each type & rating	3
1.2	Outdoor light fixture	Nos. of each type & rating	3
1.3	Switches	Nos. of each type & rating	10
1.4	Receptacles	Nos. of each type & rating	10
1.5	Receptacles (3Ph)	Nos. of each type & rating	2
1.6	MCCB	Nos. of each type & rating	5
1.7	RCBO	Nos. of each type & rating	10
1.8	MCB	Nos. of each type & rating	10
1.9	Wire coil for lighting system	Nos. of each type & rating	1
1.1	Wall mounted lighting pole	Nos.	
1.11	Switch box	Nos. of each type	
1.12	MCB Box	Nos. of each type	2
1.13	Lamps	Nos. of each type	50
1.14	Multi plug		
i)	5A/15A	Nos. of each type	20
ii)	6A/32A	Nos. of each type	10
iii)	63A	Nos. of each type	5
iv)	125A	Nos. of each type	2

CHAPTER 26: GROUNDING & LIGHTNING PROTECTION SYSTEM

26.1 Scope of Work

i) This specification covers the requirements of installation, testing and commissioning of Grounding and lightning protection systems. The work shall be carried out in accordance with this specification, relevant project layout drawings, typical drawings and installation notes enclosed with the specification.

ii) The Grounding System of the Powerhouse complex, tail race, and Transformer Yard, GIS Building shall establish a common, Low Resistance reference with respect to ground for all parts of the Project. The earth resistivity shall be measured during the detail engineering and according to the system shall be designed as per IEEE80 and IS 3043.

a) Grounding system shall consist of earth grids including treated and non-treated pits, risers, clamps, accessories and electronic Grounding and electrodes embedded in concrete inside the buildings to which all the electrical equipment, metallic structures are connected to have earth continuity for safety reasons.

b) Complete earth mat, Grounding grid & Grounding system for the powerhouse, Control building, in each floor, Switchgear, GIS, Transformer, and control room, DG house, Pothead yard, valve house, Dam control buildings, all interconnections shall be provided.

c) Lightning protection system for the powerhouse, control buildings, GIS/Transformer, switchgear room, valve house Dam control buildings, and other buildings as per project layout shall be provided.

26.2 Codes and Standards

i) The Grounding and lightning protection installation work shall conform to the latest applicable Regulations, all currently applicable standards, codes of practice and safety codes of the locality where the installation is to be carried out. Nothing in this specification shall be construed to relieve the CONTRACTOR of this responsibility.

ii) The codes and standards mentioned in the various specifications and requirements specified in the enquiry document shall be latest as on the day of award of contract of the works unless otherwise specified. Contractor shall be responsible to inform to the Consultant/ Owner in case of any revisions/reaffirm/amendment in the relevant codes and standards after the date of award of contract within 30 days of the issue of such revision/re-affirm/amendment of the code/ standard. Consultant/ Owner may approve use of the earlier code/ standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed.

iii) The CONTRACTOR shall ensure that measuring instruments and gauges to be used for testing and inspection shall have valid calibration and the accuracy can be traced to National / International Standards as applicable.

26.3 Design Criteria

26.3.1 Fault current & duration

The Grounding system shall be designed for maximum fault current of the system. Details shall be referred from system studies during detailed engineering.



26.3.2 Conductor material

The Grounding system conductors and accessories proposed are as follows:

1	Conductors above ground level and in trenches	
1.1	Generator Transformer Neutral, Unit Cum Station Transformer Neutral, Generator-Motor NGT, Lightning Arrester (LA), to Treated Earth Pit above ground level.	Copper Flat
1.2	Capacitor Voltage Transformer (CVT), Auxiliary Transformer Neutral, DG Neutral to Treated Earth Pit above ground level.	Galvanized Steel
1.3	Pothead Yard Structure, All Transformer, DG Set, LV and HV Motors, Panels Body Grounding above ground level	Galvanized Steel
2	Conductors buried in ground or embedded in concrete	Galvanised Steel
	Conductors buried in ground or embedded in concrete For Gas Insulated System (GIS)	Copper Flat
3	Electrodes	GI Pipe / Rod
4	Treated Earth Pit	GI Pipe
5	Lightning protection air termination and down conductors for buildings	Copper spike lightning rod, GS Flat
6	Shield wire	Galvanised Steel

Grounding and lightning protection system installation shall be in strict accordance with the latest editions of CEA Regulations, relevant Indian Standards and Codes of Practice, and Regulations existing in the locality where the system is installed.

a)	Code of practice for Grounding	IS 3043
b)	AC substation grounding	IEEE 80
c)	Generating Station Grounding	IEEE 665
d)	Measures relating to Safety and Electric Supply	CEA Regulation
e)	National Building Code	IS SP 7
f)	Protection against lightning	IS/IEC 62305
g)	National Electrical Code	IS SP 30
h)	Manual on Grounding of AC Power Systems	CBIP 339

The Contractor shall undertake the soil resistivity measurements as per Winner's 4 electrode method. The earth resistivity values measured shall be utilized for Grounding grid design calculations and select suitable type of conductors. Minimum cross section of main earth conductor shall not be less than 50x10mm GS / MS flat. The earth electrode shall be not less than 25mm dia of GI.

26.4 Size of conductors

i) Main Grounding Conductors

The Grounding conductor sizes shall be calculated as per IS 3043 and shall comply with Indian Electricity rules and IEEE 80.

ii) Rod Electrodes

Galvanised Iron rod electrodes of suitable diameter and length shall be used as per the recommendation of IS 3043. For test pits, electrodes shall be heavy duty type (Class – C) G I pipe of suitable diameter with perforations. Electrodes installed in the test pits shall have disconnecting facilities. The arrangement of test pits shall meet the requirement of IS 3043.

iii) Equipment Grounding Leads

iv) The size of the Grounding leads shall be decided based on the type of equipment and structure to be earthed and shall be provided generally as per IS 3043.

v) Conductors for lightning protection system

vi) The size of conductors for lightning protection system shall be decided based on mechanical strength and as per IS/IEC 62305

26.5 Grounding System

The Grounding system design and installation shall generally comply with IS 3043, IEEE 80, IEEE 665 and Indian Electricity Rules.

26.5.1 General

i) Metallic frames of all current carrying equipment, supporting structures adjacent to current carrying conductors, lightning protection system conductors and neutral points of various systems shall be connected to a single Grounding system. Two Grounding leads shall be used if rated voltage of equipment is above 250V. If the rated voltage is 250V or below, one earth lead shall be provided. Metallic structures adjacent to electrical equipment shall be earthed by one Grounding lead.

ii) Whether specifically shown in drawings or not, Steel/RCC columns, metallic stairs, handrails, etc. of the building housing electrical equipment shall be connected to the nearest Grounding grid conductor by at least one Grounding lead. Electrical continuity shall be ensured by bonding the different sections of hand rails and metallic stairs.

iii) All cable trays in the buildings as well as inside the trenches shall be connected to earth grid at an interval of about 10m.

iv) Two separate Grounding leads shall be provided for each of the Transformer (indoor and outdoor) / Generator neutrals. Each of the Grounding leads shall be directly connected to a separate treated earth pit which in turn, shall be connected to two different runs of the main Grounding grid. The neutral Grounding lead shall not touch the frame.

v) In all plants, system neutrals (transformers, generators, neutral grounding transformer / resistor and outdoor substation LAs) shall be earthed through treated earth pits only.

vi) Earth connections using stranded copper/aluminium conductor shall be provided with lugs (crimped type)

vii) Chemicals used for earth pit treatment shall not cause ground water pollution and shall not be corrosive.

viii) Number and type of earth pits at Point of Supply shall be as per the requirement of Electric Utility Company (Electricity Board) & Local Electrical Inspectorate.

ix) The grounding system shall be designed for a life expectancy of at least fifty years, for maximum fault current of the system. MS flats or rods shall generally be used as

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main ground mat. The touch and step potentials shall be maintained within acceptable limits as per relevant Institute of Electrical and Electronics Engineers or Indian Standards or International Electrotechnical Commission standards.

x) Special attention shall be made for grounding of high voltage Gas Insulated Switchgear equipment, computer networks and communication equipment as per the manufacturer's recommendations.

xi) Provision at appropriate locations shall be kept for measurement of grounding resistance at regular intervals.

26.5.2 Grounding conductor layout

i) Grounding conductors in outdoor areas shall be buried 600mm (min) below finished grade level unless stated otherwise.

ii) The spacing between adjacent electrodes shall be minimum 2000mm, unless otherwise stated elsewhere.

iii) Grounding conductor around the building shall be buried in earth at a minimum distance of 1500mm from the outer boundary of the building. In case high temperature is encountered at some location, the Grounding conductor shall be laid minimum 1500mm away from such location.

iv) Grounding conductors embedded in the concrete floor of the building shall have at least 50mm concrete cover.

v) Grounding conductors along their run on columns, walls, etc. shall be fixed by suitable welding or cleating at intervals of 1000mm and 750mm respectively

vi) Tap connections from the floor Grounding grid to the equipment/structure to be earthed shall be terminated on the Grounding terminals of the equipment, if the equipment is available at the time of laying the grid. Otherwise, "earth insert" with temporary wooden cover or "earth riser" or "Grounding pads" shall be provided near the equipment foundation/pedestal for future connections to the equipment Grounding terminals.

vii) In outdoor areas, buried conductors shall be brought 500 mm above ground level for making tap connections to equipment (above ground level).

viii) Grounding conductors crossing the road shall be either installed in Hume pipes or laid at greater depth to suit the site conditions.

ix) Wherever Grounding conductor cross underground service ducts, pipes, trenches, tunnels, railway tracks, etc., it shall be laid in Hume pipes at minimum 300 mm below them. The Grounding conductor shall be re-routed in case it fouls with equipment foundations.

x) Wherever Grounding conductor passes through walls, floors, etc. galvanized conduit / HDPE pipe sleeves shall be provided for the passage of the conductor. Both ends of the sleeve shall be sealed to prevent the passage of water through the sleeves. The seals, in addition, shall be fire proof if the specifications/project drawings call for the same.

xi) Grounding of Electronics, including Instrumentation and control systems, shall include dedicated earth pits.

26.5.3 Grounding system installation

i) The spacing between two electrodes shall be at least equivalent to twice the length of the electrode.

ii) Grounding conductor running exposed on column, walls, etc., shall be supported by suitable cleating, at intervals of 750mm.

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iii) The Grounding conductor crossing the road / track shall be laid in Hume pipe or laid at a greater depth to avoid damage.

iv) When earth conductor passes through floors, walls, etc., suitable pipe sleeves shall be provided and the same shall be sealed after installation.

v) The connection between Grounding pads / terminal to the earth grid shall be made short and direct and shall be free from kinks & splices.

vi) Metallic conduits and pipes shall not be used as earth continuity conductor.

vii) Street lightning poles, flood light poles & towers, their junction boxes shall be connected to the Grounding conductor to be run along with supply cable. This earth conductor shall be in turn connected to earth grid at two extreme points.

viii) Flexible earth conductors shall be provided at expansion joints for Grounding the gates, operating handles etc.

ix) Equipment bolted connection after being checked and tested shall be painted with anti-corrosive paint / compound.

x) Connection between the equipment earth lead and the grid conductor shall be welded. For rust protection, the welds shall be treated with zinc chromate primer and coated with zinc rich paint.

xi) The cable sheaths screens armour shall be earthed at both ends for multi-core cables. For single core cables the same shall be done at one end (switchgear end) only.

xii) All bimetallic connections shall be treated with suitable compound to prevent moisture ingression.

xiii) Electronic earth pit for PLC/SCADA/I&C equipment shall be provided. Insulated copper cables shall be used for electronic Grounding.

xiv) Electrical conduits, pipes and cable tray sections shall be bonded to ensure electrical continuity and connected to Grounding conductors at regular intervals. Apart from intermediate connections, end and beginning points shall also be connected to Grounding system.

xv) Steel/RCC columns, metallic stairs, handrails, cable trays, metallic conduits and pipes shall not be used as earth continuity conductor.

xvi) A separate Grounding conductor shall be provided for Grounding luminaire, receptacles, switches, junction boxes, lighting conduits, poles, etc. This conductor in turn shall be connected to the main earth.

xvii) Steel pipe racks in the process units and off-site areas should be earthed at every 25m and at minimum 2 points.

xviii) Connection between equipment Grounding lead and main Grounding conductors and between main Grounding conductors shall be welded/brazed type. For rust protection, the welds should be treated with zinc chromate and afterwards thickly coated with bitumen compound / bitumastic paint to prevent corrosion.

xix) Steel to copper and copper to copper connections shall be brazed type. Welding shall be adopted in case of steel. Welding shall be done as per IS 816.

xx) The jointing, whether bolted, welded or brazed shall be such that the resistance of the joint is not more than the resistance of the equivalent length of the conductor.

xxi) All welded connections shall be made by electric arc welding. All welded joints shall be allowed to cool down gradually to atmospheric temperature before putting any load on it. Artificial cooling shall not be allowed.

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a) Main Grounding conductors shall be buried in earth around the building. More than two taps-off from this Grounding loop shall be taken inside the building and connected to the Grounding grid embedded in the floor slab with approximately 50mm concrete cover.

b) Each RCC / Steel column of the building shall be interconnected to the floor Grounding grid.

c) Cable trays, steel pipes / conduits, steel columns, etc., shall not be used as earth continuity conductors.

d) All electric system equipment shall be provided with a dedicated Grounding system suitable for the equipment.

e) Grounding grids of the buildings, outdoor yards shall be interconnected to form a single grid.

f) Grounding grid design shall be done in such a manner that the grid resistance is less than one ohm. The Contractor shall furnish the Grounding and lightning protection design calculations and detailed Grounding and lightning protection layout drawings for purchaser's approval.

xxii) If required, For UPS / SCADA an independent Grounding system and electrodes shall be provided based on the recommendation of SCADA supplier.

xxiii) The shields or armour of three core power cables shall be earthed at both ends whereas the same for single core cables will be done at supply end only. Three Core Cables - The shields of solid type cables are earthed at terminations provided cable sheaths are bonded at joints. Single core cables - The sheaths of single core cables shall be earthed at the trifurcating box. In case of single core mains, Grounding shall be done at the end of trefoil formation and the cable glands at sealing ends.

26.6 Lightning protection system

The powerhouse building and the scope as covered in the tender specification shall be provided with lightning protection system.

i) Lightning Protection System Layout

a) The lightning systems design and installation shall generally comply with IS/IEC 62305 code of practice for the protection against lightning.

b) Each down conductor shall be connected to a rod electrode, which in turn shall be connected to the Grounding system through test links.

c) All the buildings, equipment & structures shall be provided with Lightning protection.

ii) Lightning Protection System Installation

a) Conductors of the lightning protection system shall not be connected with the conductors of the safety Grounding system above ground level.

b) Down conductors shall be cleated on outer side of the building wall at 750 mm interval or welded to outside building columns at 1000 mm interval

c) Connection between each down conductor and rod/pipe electrode shall be made via test link located approximately 1000 mm above ground level.

d) Lightning conductors shall not pass through or run inside GI conduits.

e) All metallic structures within a vicinity of 2000 mm in air shall be bonded to the conductors of lightning protection system

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f) For outdoor substations and switchyards, Lightning Mast shall be provided for lightning protection.

g) In case of installations demanding use of shield wires, the shield wires shall comprise 7/3.65 mm, 70 mm2 galvanised steel wire strung across pinnacles of the tower structures or separate lightning masts. These shall be brought down on every alternate tower, cleated along the tower leg, up to the test link mounted at 1000 mm from ground level. Conductors from test links shall be connected to separate rod/pipe electrodes (which in turn shall be connected to main grid).

h) Wherever required, for fuel-oil and other inflammable liquid storage tanks lightning protection shall be provided with horizontal conductors strung between tall poles covering the entire area.

i) Lightning conductor on concrete roof will not be directly cleated on surface of the roof. Concrete upstands shall be used for conductor fixing at an interval of 1500 mm

j) Joint in the down conductors, if unavoidable, shall be of welded type. However, number of joints in the lightning conductor shall be kept minimum

k) Down conductor shall follow a straight path to earth. There shall not be any sharp bends, turns and kinks in the down conductors.

l) The lightning protection system shall not be in direct contact with underground metallic service ducts, cables, conduits, and metal enclosure of electrical equipment. However, all metal projections, railings, vents, tanks etc. above the roof shall be bonded together to form a part of roof grid.

26.7 As Built Drawings

Any changes in Grounding conductor / lightning protection conductor layout carried out by CONTRACTOR to suit the site conditions, shall be incorporated in the relevant project drawings by the CONTRACTOR for which the PURCHASER / ENGINEER will furnish soft copy of the original drawings. The CONTRACTOR shall submit hard and editable soft copies after incorporating all changes carried out at site and forward the same to PURCHASER / ENGINEER for further action

26.8 Tests

After the installation of the earth grid, the Contractor shall carryout the Grounding system resistance measurements. If the value of the earth resistance is not meeting the design value (1 Ohm), additional earth rods and earth conductors shall be installed to improve the earth resistance to the design value.

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26.9 Mandatory spares

Sl. No	Grounding & Lightning	Quantity & Particular
1	**Equipment**	
1.1.	Earth busbar	10 Nos. of each type & rating
1.2.	Connectors, Bolts, Nuts, washers, Lugs, clamps, screws, fasteners, etc.	10 sets of each type & rating
1.3.	Junction boxes	10 Nos of each type & rating
1.4.	Link Boxes	5 Nos. of each type & rating
1.5.	Grounding rod / pipe with accessories	5 Nos. of each type & rating
1.6.	Lightning rod with mounting accessories	5 Nos. of each type & rating

CHAPTER 27: EMERGENCY DIESEL GENERATOR AND ACCESSORIES

27.1 Scope of Work

This specification covers the general design, materials, construction features, manufacture, shop inspection and testing at the manufacturer's works, delivery at site, handling at site, including transit insurance, erection, testing, commissioning, performance testing and handing over of Diesel Generator sets with acoustic enclosure.

27.2 Capacity of DG Sets

The DG set shall be capable of giving a continuous output (refer below) at the generator terminals under site condition with an overload capability of 10 % for one (1) hour in twelve (12) consecutive hours of operation. The DG rating indicated below are a minimum, however, higher rating shall be considered as per project requirement.

27.3 Khorlochhu HPP DG Set Quantity:

i) 1250 kVA, 11 kV, 50Hz, DG set for Powerhouse - 2 nos. (1 Main and 1 Stand By).

ii) 315kVA, 415V, 50 Hz, DG set for Dam site and Butterfly valve area LT. - 2 nos.

iii) 125kVA, 415V, 50 Hz, Chaplangchhu Intake area LT Board. - 1 nos.

27.4 Equipment & Services to be Furnished by The Vendor

Three phase, 11 kV (or) 415V, 50 Hz, prime rated diesel generating set consisting of radiator type cooled diesel engine coupled to an alternator and mounted on common base plate complete with fuel tank (10 hours capacity), auto main failure panel, control panel and other standard accessories with anti-vibration mountings for installing the diesel generator set shall be provided.

i) **Engine fuel oil system shall include the following**

a) Fuel oil Day tank for HT DG set 990 litter & for LT DG set 490 litter.

b) One hand operated diesel oil transfer pump suitable for wall or floor mounting to transfer oil from barrels to 'Day' tank,

c) 1x100% capacity duplex filters or 2x100% capacity individual filters,

d) Sufficient length of flexible hose pipe for the hand operated diesel oil pump suction and discharge,

e) Complete interconnecting piping along with all necessary valves, fittings instrumentation and supports inside DG house.

ii) **Lube oil system shall include the following:**

a) Engine driven pumps,

b) Water cooled oil coolers with bypass arrangement in water side,

c) Thermostatically controlled electric heaters for lube oil, if ambient conditions warrant the same,

d) Lube oil level indicator and lube oil sump strainer,

e) 1x100% capacity duplex filter or 2x100% capacity individual filters,

f) The lube oil system shall be designed to remain primed with lube oil at all times. If required, lube oil priming pump shall be included in the scope of supply by the Bidder,

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g) All necessary piping, valves, fittings, instrumentation and supports,

The initial charge of lubricating oil for the engine shall also be included in the scope of supply by the Bidder.

iii) The heat exchangers for cooling lube oil jacket water shall be water cooled Shell and Tube type confirming to TEMA-C or Approved equal.

iv) Jacket water system shall be complete with engine driven pump, thermostatically controlled jacket water pre-heater, if required, all necessary piping, valves, fittings, instrumentation and supports, expansion tank, if required. For cooling the jacket water, radiator with fan shall be provided with by-pass arrangement on jacket water side complete with the by-pass valve.

v) The diesel engine shall be suitable for electric starting, and the necessary battery and battery-charging arrangement shall be supplied by the bidder.

vi) The air intake and exhaust system shall be provided with air intake filters and silencers, exhaust gas driven turbo charger, charge air cooler, exhaust gas residential type silencer. Exhaust silencer and exhaust piping shall be insulated and be taken to a point above the roof of the building. Necessary supports for exhaust piping shall also be provided by the bidder.

vii) Exhaust Stack height for DG set shall be considered in line with latest Central pollution control board (CPCB) / local statutory requirement. However, at HPP powerhouse location, minimum height of stack 30 meter for DG sets shall be provided and comply with latest Central pollution control board (CPCB) / local statutory requirement.

viii) The exhaust stack shall have a suitable rain protection cover on the top.

ix) The governor characteristics shall be complete with the requirements of 'Class-A1' governing of ISO-3046 unless otherwise specified.

x) All necessary cabling for equipment supplied under this contract is included in the vendor scope.

xi) Foundation bolts and other necessary erection materials at site.

xii) Performance testing at shop and at site.

xiii) Operation and instruction manuals.

xiv) Bidder shall indicate all equipment proposed to be mounted on the control panel. The control panel shall consist of but not be limited to the following:

a) One (1) Voltmeter,

b) One (1) red lamp to indicate DG Operating,

c) One (1) green lamp to indicate DG set off,

d) Any protection required.

xv) Dial type thermometers and pressure gauges shall be provided as per the engine manufacturer's standard practice.

xvi) AMF panel completely pre-wired with fully automatic mains failure (AMF) feature comprising controls, interlocking system, relays, instruments, annunciation system, wiring, etc as detailed in single line diagram.

xvii) Power, control and instrumentation cables between DG set, AMF panel and Switchgear.

xviii) All necessary instrumentation.

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xix) All start-up spares as required and essential spares.

xx) Bidder shall furnish their general arrangement drawing of DG set and accessories.

xxi) Bidder shall indicate the conditions under which the DG set shall be tripped.

27.5 Generator

i) Generator shall be mounted on a common base frame together with the prime mover.

ii) The Generator shall be totally enclosed air-cooled type. The Generator shall be star connected.

iii) The Generator and field windings shall be class H insulated with temperature rise limited to class F limits. Refer data sheet-A.

iv) Resistance temperature detector (RTD) shall be installed at the following locations:

a) 6 Nos. duplex or 12 nos. simplex RTDs in stator windings

b) 1 No. duplex RTD in each bearing

v) The stator windings shall be brought out to six insulated terminals in two separate terminal boxes. The alternator shall, be provided with three separate terminal boxes i.e. for the live and neutral stator connections and for control connections. The star connection shall be formed in the neutral terminal box. Terminal box shall be capable of withstanding short circuit current for 1 sec.

vi) Space heaters suitable for operation on 1 phase, 240V AC shall also be provided.

vii) All terminals shall be of stud type. The terminal boxes shall be complete with lugs and double Compression cable glands.

27.6 Excitation System

i) Generator shall be provided with brushless type excitation system. The excitation system shall include digital automatic voltage regulator.

ii) The exciter capacity shall be at least 10% more than the maximum requirement at any time. The exciter winding shall be insulated with class H insulation with temperature rise limited to class F limits.

iii) Automatic microprocessor based digital voltage regulator shall be provided with necessary protections and limiters. The AVR shall be able to maintain constant rated voltage for entire load range capability of the generator. The AVR shall be provided with one channel for auto control and one channel for manual control.

27.7 AMF Control & Relay Panel

i) The Control & Relay panel for the generator set shall comprise of protection and metering equipment, indicating instruments etc with breaker panel.

ii) Numerical protection relays shall be provided which shall be suitable to interface with Plant SCADA via IEC 61850 protocol. Composite generator protection relay shall be provided.

iii) All auxiliary devices for control, indication, measurement, protection and alarm shall be mounted on the front door of the panel.

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iv) An adequately sized earth bus shall be provided in the panel for connection to the main earth grid. All noncurrent carrying metallic parts of the mounted equipment

v) shall be earthed. Doors and movable parts shall be earthed using flexible copper connections.

vi) Engraved nameplates shall be provided for all devices mounted on the front of the panel.

vii) AMF panel completely pre-wired with fully automatic mains failure (AMF) feature comprising controls, interlocking system, relays, instruments, annunciation system, wiring, etc.

viii) Necessary pressure switches, level switches, thermostats, flow switches, auxiliary relays etc. required for the above shall be provided.

ix) Remote monitoring and control facility for DG set to be considered.

27.8 Performance Requirements

i) The diesel engine shall be capable of operating continuously with high-speed diesel as available commercially without the pretreatment.

ii) The diesel generator shall be capable of giving a net output of the value as indicated in above clause-2 at three phase voltage at the generator terminals after derationing, if any required.

iii) Diesel engine shall operate satisfactorily while exhausting without visible smoke.

iv) Noise level shall be 75 dBA at 1 m from the DG set. Adequate acoustic enclosure required shall be included for the DG set.

27.9 General

i) The design, manufacture, inspection, erection, testing and commissioning and performance testing of the diesel generator and accessories shall comply with all currently applicable statutes, regulations and safety codes in the locality where the diesel generator will be installed and the latest applicable codes and standards. Nothing in this specification shall be construed to relieve VENDOR of his responsibility.

ii) The Diesel engine generating set shall be designed for outdoor mounting.

iii) All statutory clearances required for the installation of the diesel generator set shall be obtained by the contractor.

iv) Type test reports Shall be as per IS/ IEC.

v) Vendor shall carry out shop tests in the presence of Purchaser / Engineer to demonstrate the performance of the equipment supplied by him. Test certificates in this regard shall be submitted to Purchaser / Engineer for approval.

vi) In addition to the above, Vendor shall also submit hydro test certificates for the engine jacket, Lube oil cooler and charge cooler for Purchaser's / Engineer's Approval.

vii) DG set parameters to be made available on HMI at control room.

viii) Load testing at site minimum 2 hours shall be considered.

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27.10 Spares

i) The bidder shall submit a list of recommended spares required for initial five (5) years of trouble-free operation.

ii) The final spare list shall be decided by the PURCHASER / ENGINEER in consultation with the bidder. The bidder shall supply these spares along with the switchgears.

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27.11 Employer's Specifications

Sl. No.	Item	Unit	Client Specification		
1	**General**				
1.1	Designation		Diesel Generator		
1.2	Numbers Required		As per SLD		
1.3	Type	Manually started/ AMF	AMF		
1.4	Fuel		High speed Diesel		
1.5	**Site Conditions**				
i)	Altitude – above mean sea level	M	<1000 m		
ii)	Maximum ambient temperature	°C	50		
iii)	Relative humidity	%	95%		
2	**Design Data**				
2.1	Continuous output at site conditions	kW			
2.2	Overload capability for one hour in one full day of working		10%		
2.3	Rated kVA	kVA	1250 kVA	315 kVA (415V),	125 kVA (415V),
2.4	Power factor		0.8		
2.5	Rated voltage		11kV (No load)	415 V (No load)	415 V (No load)
2.6	Rated Frequency		50Hz		
2.7	Winding connection		Stator- Double layer lap		
2.8	Type of insulation				
i)	Armature Windings		Class H		
ii)	Field Windings		Class H		
iii)	Commutator		Class H		
iv)	4 core connection		Class H		
2.9	Type of enclosure		IP 55 with weather proof		
2.10	Permissible voltage variation at rated kVA, speed, power factor		±10%		
2.11	Method of neutral grounding		NGR for 11 kV DG Set, and Solid Grounding for 415 V DG		
2.12	Permissible frequency variation At rated kVA, speed and pf	%	± 5 %		

Sl. No.	Item	Unit	Client Specification
2.13	Largest motor to be started with Drop in the generator terminal Voltage less than 15% with full Base load		*
2.14	DOL /star delta:	kW	*
2.15	Parallel operation		
i)	If more than one dg is in Operation, whether in isolation/ In parallel		
ii)	DG in parallel with the grid Continuously:	yes/no	
iii)	DG in parallel with the grid / Unit Momentarily:	yes/no	Yes
iv)	Are under frequency load shedding schemes required: es	yes/no	NA
v)	Type of under frequency relay		
vi)	Load shedding requirements		
vii)	Protection requirements:		Refer Single line diagram
2.16	Harmonic loading (if any): current	%THD	±<5% no load to full load
2.17	Size of conductor cables:	C x mm2	*
2.18	Period for taking load from 'start' impulse	sec	*
2.19	Engine Starting System		Electric
2.20	Battery and battery charger:	Yes/No	Yes
2.21	Excitation system: static / brushless		Brushless
2.22	Manual start/stop of engine through local / remote push button required	Yes/No	Yes
2.23	Trip device on main supply restoration required		Yes
2.24	Stopping of DG set		Auto
2.25	Governor class	A1 / A2	A1
2.26	Response to step change of load: switch-in and/or throw-off		*
2.27	Speeder gear operation on dc voltage for remote variation of speed required	Yes / No	*
2.28	Maximum time of operation without cooling water availability during start up	min	*
2.29	Generator switchgear By contractor / purchaser		*

Sl. No.	Item	Unit	Client Specification
2.30	Motors: By contractor / purchaser		*
2.31	Engine cooling system: water Cooled heat exchanger / Radiator with engine driven fan		Radiator with engine driven fan
2.32	Cooling tower: by contractor/ Purchaser		*
2.33	Cooling water pumps: By contractor/ purchaser		*
2.34	Cooling water /make-up water Quality		*
2.35	Cooling water inlet Temperature:	°C	*
2.36	Maximum allowable cooling water temperature rise :	°C	*
2.37	Cooling water inlet pressure	kg/cm2(g)	*
2.38	maximum allowable cooling water pressure drop	kg/cm2	*
3	**Accessorise** *		
3.1	**Equipment Accessories**		
i)	Coupling and coupling guard.		
ii)	Exhaust pipe/ steel stack:	Yes/No	
iii)	Tacho generators :	Yes/No	
iv)	Ac motor driven priming oil pump With clock timer	Yes/No	
v)	Battery voltmeter	Yes/No	Yes
vi)	Winding and bearing RTDs for Generator:	Yes/No	Yes
vii)	Engine coupled with generator **a) one (1) hour at 50% load** **b) one (1) hour at 75% load** **c) four (4) hours at full load** **d) followed by one (1) hour continuous load of 110%**		
4	**Tests and Inspection**		Yes
4.1	Generator		

Sl. No.	Item	Unit	Client Specification
	Type and routine tests as per standard IS 4722 / BS 5000 part 99		
4.2	Exciter Type and routine tests as per standard is 4722 / bs 5000 part 99		
4.3	Voltage regulator tests as Per IS / BS		
4.4	Continuous output at site Conditions	+ kW	
4.5	10% overload for one(1) hour Out of a total of 12 consecutive Hours of operation without Overheating		
4.6	Fuel oil consumption at 50%, 75% And full load:	+ Gms/kWhr	
4.7	Lube oil consumption:	+ Gms/kWhr	
4.8	Cooling water temperature at Engine outlet:	+ °C	
4.9	Cooling water pressure drop:	kg/cm2	
4.10	Noise level	db(a) at m	
5	**Spares And Maintenance Tools And Tackles** *		
5.1	Essential spares		5 Years recommended spares
6	**Miscellaneous**		*
6.1	Painting	Synthetic enamel/ Epoxy	
6.2	Proposed Layout: as per general arrangement drawing		

27.12 Applicable Standards

Sl No.	Particular	Reference
1	Specification for performance requirements for constant speed compression ignition (Diesel) engine for general purposes (above 20KW).	IS: 10002
2	Specification for reciprocating Internal Combustion Engine	BS : 5514
3	Methods of tests for Internal Combustion Engine.	IS : 10000
4	Rotating Electrical machines.	IS : 4722/ IEC 60034
5	Rotating Electrical Machines of Particular type of for particular applications. Generators to be driven by reciprocating Internal Combustion Engine.	BS : 5000
6	Specification for direct acting indicating instruments and their purposes.	IS : 1248
7	Mild steel tubes and fittings.	IS : 1239
8	Color for supply ready mixed paints and enamels	IS : 5
9	Reciprocating internal combustion engine	BS 5514/ISO 3046

27.13 Mandatory Spares: -

Sl. No.	Equipment	Quantity and Particulars
1	**Miscellaneous**	
1.1	Piston Ring oil ring set – for complete engine	1 set of each type & rating
1.2	Cylinder head gaskets – for complete engine	1 set of each type & rating
1.3	Fuel injector assembly complete with valve and holder – for complete engine	1 set of each type & rating
1.4	Fuel injector valve set – for complete engine	1 set of each type & rating
1.5	Compressed air system – service kit	1 set of each type & rating
1.6	Inlet/ exhaust valves – for complete engine	1 set of each type & rating
1.7	Packing gaskets, O-rings and seals – for complete engine	1 set of each type & rating
1.8	Bearings shells – for complete engine	1 set of each type & rating
1.9	Lubricating oil filter	1 set of each type & rating
1.10	Instruments, sensors & transducers	1 set of each type & rating
1.11	V-belts, timing belts – for complete engine	1 set of each type & rating
1.12	Starting/crank assembly (including motor, solenoid, etc.,)	1 set of each type & rating
1.13	Fuel shut-off solenoid valve	1 set of each type & rating
1.14	Fuel filter element	1 set of each type & rating
1.15	Air filter element	1 set of each type & rating
1.16	Resistive load bank circuit contactor	1 set of each type & rating
1.17	AVR (Auto Voltage Regulator)/ AVR card	1 set
1.18	MCB/MCCB	1 no. of each type
1.19	Governor card	1 no. of each type
1.20	Contractors	1 no. of each type
1.21	Breaker Control Switch	2 nos. of each type
1.23	ON/OFF switch, 2 and 3 way switch, selector switch	2 nos. of each type
1.24	Valves	2 nos. of each type
2	**Generator & Control system**	
2.1	Collector brush holders	1 set of each type & rating
2.2	Collector brush sets	1 set of each type & rating
2.3	Excitation/AVR system modules & printed circuit cards	1 set of each type & rating
2.4	Bearings	1 set of each type & rating
2.5	Control panel electrical components	1 set of each type & rating



CHAPTER 28: LUBRICATION OIL HANDLING & PURIFICATION SYSTEM

28.1 Scope of Work

Scope of work under this chapter covers the provision of labour, tools, plants, materials and performance of work necessary for the design, manufacture, quality assurance, quality control, shop assembly, shop testing, delivery at site, site storage and preservation, insurance, installation, commissioning, performance and acceptance testing, training of Employer's personnel, handing over to KHPL and guarantee for three years of lubrication oil handling and Purification system as per the specifications hereunder, complete with all auxiliaries, accessories, spare parts and warranting a trouble free safe operation of the installation. The System shall be suitable for Ambient, Seismic, Altitude and other site conditions are detailed in General Technical Specifications.

The scope of work shall be a comprehensive functional system covering all supply and services including but not be limited to following:

28.1.1 Vacuum Type Insulating Oil Handling System

i) Two (2) 6000 LPH or higher mobile skid mounted insulating oil purifying plants complete with transformer evacuation system, oil hoses, vacuum hoses, hose couplings and other accessories to complete the system,

ii) Two (2) regenerative air dryers of suitable capacity for generator transformers,

iii) Two (2) 300 LPH or higher mobile skid mounted insulating oil transfer pump with oil hoses, hose coupling and other accessories,

iv) One (1) mobile tyre mounted insulating oil tank of capacity of 9000liters.

v) One (1) skid mounted separate transformer evacuation system for transformer tank evacuation.

28.1.2 Lubrication Oil Handling System

i) Two (2) nos. oil pumps for lubricating oil capable of delivering oil at the discharge rate of 4 m3/hr. & at a pressure of 6.0 kg/cm2 and against a suction head of approximately 15 m, complete with motor, motor control, pressure gauge, filter, relief devices and other accessories essential for satisfactory operation.

ii) Two (2) nos. lubricating oil purifiers of capacity 4 m3/hr. complete with centrifuge, oil pump with motor, motor control, heaters & heater control, thermostats, controls, protection, gauges, piping and valves and other accessories required for satisfactory operation.

iii) Two (2) nos. lubricating oil storage tanks of capacity not less than 15 m3 for lubricating oil.

iv) Two (2) nos. barrel pump of capacity not less than 0.5 litres/sec.

28.1.3 Miscellaneous Components and Auxiliary System

i) Spare parts in accordance to clause 9.12 "Spare Parts" of this chapter.

ii) Tools and Instruments in accordance to clause 9.14 "Tools and Instruments" of this chapter.

Any other item(s) not mentioned specifically but necessary for the satisfactory completion of work defined above, as per accepted standard(s) best international practices.

28.2 Specific Design and Layout Conditions

28.2.1 General

The oil handling systems shall cater to the needs of lubricating oil for Generating units, governor, & MIV.

Lubricating oil handling system shall be capable of fulfilling the needs of various bearings of Generating Units (Unit 1 to 4) as well as oil of Governors and Main Inlet Valve's OPUs. The pumping pressure requirement of each system shall be calculated on the basis of filling/draining of the oil at the farthest end of generating Unit bearings/OPU.

28.2.2 Insulating Oil Handing system

Suitable arrangement/provision shall be made in the system/system components such that the plant can be docked near each of the transformer units for the intended purpose. The contractor shall ensure adequate coordination while designing the system to ensure compatibility of inlet outlet ports between he transformers and oil handling equipment.

The oil hoses for each plant shall be of sufficient length (minimum 125m) and size to filter the oil of any transformer unit by placing the filtration plant a tone of the transformer cavern. The vacuum hoses shall also be of sufficient size and length for evacuation of the transformers.

28.2.3 Scheme for Lubricating Oil for Generating Units and OPUs of MIVs and Governors.

This system shall consist of one dirty oil tank & one clean oil tank, both the tanks complete with accessories such as level gauges, air vent pipe, overflow pipe, inlet and outlet flange/coupling connections, sample values, drain valves etc., one fixed oil purifying in oil room with all accessories to purify oil and one movable/portable oil purifier to purify the oil at each location of Generator/Turbine bearings and OPUs of governors and MIVs, one fixed oil pump with a bypass arrangement in oil room and one movable/portable oil pump, valves fitting and other accessories required for storage, filling, purifying, draining and circulation of oil used for Generator/Turbine bearings, OPUs of governors and MIVs.

The quantity of lubricating oil to be handled for each generating unit shall be approximately 15.0m^3. One oil filling pipe header and one oil drain pipe header each of 50mm dia. both common for all the units shall be laid in the ceiling of generator floor EL 779.5m from lubricating oil plant room located in Annex Bay (Unit No. 4 side) at EL 582.0m to the Generating Unit Nos. 4 to 1. Two nos. M.S cabinets/valve boxes provided with viewing glass on the front side, suitable for accommodating two valves and one non-return valve shall be provided on the fill and drain header at the generator floor (EL. 779.5m). Each cabinet/valve box shall be common between the two generating units. These valve boxes shall be used for filling/draining of oil baths of bearing of hydro generator by connecting hose. A total of two nos. of tappings one on each oil header shall be provided on oil header branch pipes to connect the above mentioned M. S. cabinets/valve boxes located at turbine floor (EL 775.0m) through 150 mm dia. sleeve provided on the B-line side of power house adjoining the columns. The two valve boxes at turbine floor, each common for two units shall be used for filling/draining OPUs of governors and MIVs at EL 775.0m and turbine guide bearing oil baths through connecting hose. A valve box in the lubricating oil room shall be provided for filling/draining of clean/dirty oil tanks from road tanker or oil barrels.

The above system and various design operations are illustrated in the Drg. No. WAP/KHO/EM-111.

28.2.4 Insulating oil purifiers

The insulating oil purifiers shall be of filtration and vacuum de-hydration type. Unit shall consist of coarse filter, oil transfer pump, thermostatically controlled ceramic heaters, filtration section, deoxidizing column, vacuum pumps, discharge pump, two stage degassing system, transformer evacuation system, thermometers, pressure / vacuum gauges, flow meter valves, piping, control panels with on-line process monitoring facilities and other accessories necessary for satisfactory operation of purifiers. The insulating oil purifiers shall be suitable for indoor and outdoor duties.

The manufacturer shall select the operating temperature and size of the oil heater to heat the oil from normal room temperature to the design operating temperature. The heaters used shall be ceramic type sealed heaters.

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Vacuum gauges to monitor vacuum shall be provided at various stages in the transformer evacuation system and in the external pipe beyond the isolation valve for external system.

28.3 Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS)/International Standards as given below except where modified and/or supplemented by this specification.

Sl. No.	Standard	Particulars
	ISO 9001	Quality Systems – Model for Quality Assurance in Design, Development, Production, Installation and Servicing.
	ASME Code VIII	Code for Unfired Pressure Vessel
	ASTM A516	Standard Specification for pressure vessel plates, carbon steel for moderate and lower temperature service
	IS 325	Specification of induction motors
	IS 1012	Specification for Turbine Lubricating Oil
	IS 1239 (Pt. I)	Mild steel tubes, tubular and other wrought steel fittings Pt. I - Mild steel tubes.
	IS :1239 (Pt. II)	Mild Steel tubes, tubular and other wrought steel fittings Pt. II - Mild steel tubular and other wrought steel pipe fittings.
	IS : 6202	Flat glass oil level gauges for oil storage tanks.

28.4 Type of Oil System

The system shall be suitable for handling oil conforming to the latest version of IS: 1012.

28.5 Rating and Functional Characteristics

28.5.1 Insulating Oil handling System

The purifier shall be capable of processing the oil on single pass basis at rated flow to the following specification:

i) Moisture content : Less than 5 PPM

ii) Gas content : Less than 0.1% by volume

iii) Dielectric :70kV across 2.5mm gap

iv) Filtration : Less than 1 micron

v) Power Factor Tan Delta at 90DegC :0.002

28.5.2 Transformer evacuation system

i) Capacity to have an ultimate blank-off of 10-4 Torr or less,

ii) Evacuation to the level of 0.1 Torr or less when connected to main transformer tank

28.5.3 Lubrication oil handling system

The purifier shall be capable of processing the lubricating oil on not more than two (2) passes basis at rated flow to the following specification:

i) Free water : 100% reduction

ii) Moisture content : Less than 50 PPM

iii) Filtration : Less than 1 micron

28.6 Performance Criteria & Guarantees

i) The supplier shall have to guarantee the performance of oil purifier in order to ensure the quality of oil purified through them. The supplier shall also guarantee the capacity,

discharge pressure, power consumption and efficiency of each oil pump, oil purifier and vacuum pump and noiseless and smooth operation of whole system. If the equipment fails to conform to the guarantees as specified in Data Sheets of Volume-6, the supplier shall make necessary modifications to ensure performance in conformity with the guarantees.

ii) If the supplier fails to bring the equipment up to the guarantees, the Purchaser shall have the right to reject the equipment. Any part found defective within three years from the date of commissioning at site, shall be replaced free of charge by the supplier.

iii) Detail calculations, including friction and other losses in piping, valves, etc., taken into consideration, the pressure requirement and capacities etc. of all pumps and purifiers proposed to be offered shall have to be submitted along with the bid.

28.7 Design and Construction

28.7.1 Oil Purifier

28.7.1.1 Capacity and Service Requirement.

Two (2) nos. lubrication oil purifier unit of the centrifuge type, with a capacity of not less than 4m^3/hr. shall be provided for the lubrication oil system. The lubricating oil purifying unit shall be used to purify and recondition lubricating oil of the governors, MIVs & OPU systems as well as the thrust and guide bearings of the main generators and turbines in the powerhouse (One or single type Lub oil to be used). One unit shall be stationary type and shall be permanently connected into a piping system of the lubricating oil for purifying and storage tank and one unit shall be portable type. Dirty lubricating oil shall be taken from the dirty oil tank, passed through the purifier, circulated in the purifier till this oil becomes clean and then discharged into the clean oil tank. The lubricating oil may contain free and dissolved moisture of the order of 1000 to 2000 PPM initially which needs to be reduced in the range of 50 PPM or less. Besides moisture, the oil may contain suspended impurities such as cotton waste, welding slag and spatters, metallic chips, small sand particles, iron fillings, pebbles, dust and pipe scales. The offered equipment shall not be damaged by the flow of oil containing these impurities. The oil may also contain grease and kerosene, which shall also be required to be removed. The purifier shall reduce the free and dissolved moisture in the lubricating oil to acceptable level for re-use. The content of mechanical impurities in the oil at outlet of unit after cleaning shall not be more than 50 ppm for centrifugal unit. Nominal thinness of filter shall not be more than 5 microns. The purification shall be such that the lubricating value of oil shall be maintained and there shall be no increase in acidity of oil due to purification process. Additives such as rust inhibitor, oxidation inhibitor shall not be removed from oil during any stage of purification.

The purifier shall be so designed as to permit the following operations:

i) Pumping with or without the heaters,

ii) Pumping with the heater and centrifuge in operation.

28.7.1.2 General Construction

The purifier shall be a standard product of the reputed manufacturer, of a design which has been proved reliable and satisfactory in the service intended. It shall be a compete, self-contained, and enclosed unit, with centrifuge, centrifuge motor, motor driven pump, electric heaters, automatic temperature control, thermometers, strainers, meters, pressure and other gauges, valves, piping, electrical control equipment for each devices/equipment, power & control cables and all other accessories as required for satisfactory operation of such a purifier.

28.7.2 Oil Storage Tanks

The oil tanks shall be cylindrical, of welded steel construction and shall be designed and fabricated from plate steel conforming to ASTM A516 Grade- 60 in accordance with part UW of the ASME Code for Unfired Pressure Vessels, Chapter VIII, for the design. It shall be mounted vertically on suitable saddles. A spreader plate underneath the tanks located in the

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lubricating oil room shall be provided for reducing load intensity on the lubricating oil room floor. The top end of each of the tank shall be flat and bottom end shall be conical, the Tank shall have two hermetically sealed manholes for inspection and cleaning purposes, one at the sides of lower portion of the tank and another on top in tank cover and necessary gauge glasses and level indicators to show oil level etc. shall also be provided. The manholes shall have bolted down covers. The tank shall have oil supply and discharge connections. The tank shall have oil supply and discharge connections. The tank shall also be provided with a sampling cock, an overflow line and air vent pipe, etc. and total drain connection (with valve) at the bottom. All tank vents shall be fitted with dehydrators to prevent the entry of moisture into the tanks. One 100mm dia. Dial type thermometer, having scale range of 15°C to 100°C shall also be provided on the tank. Suitable stiffeners shall be provided for imparting rigidity to the tank. Mild steel rungs shall be welded on the tank at adequate distances to act as ladder. Tanks shall be equipped with special filters for drying and cleaning air, entering into tank. The height of each tank shall be limited to 3.0 m due to civil constraints.

All tanks shall be suitable for indoor installation. Normally the oil tanks shall remain empty & these will be filled with oil at the time of fresh arrivals and reconditioning of oil during capital maintenance of the generating units. The thickness of tank plate shall be of sufficient size for temperature effect and pressure due to oil. However, it shall not be less than 8 mm for shell and 10 mm for dish end. The supplier shall furnish the complete design calculations regarding the capacity of the storage tanks as per relevant Indian Standard for the approval of the purchaser during design stage. The tank shall be tested for a pressure of 35kpa plus the maximum hydro static pressure carrying on the bottom of the tank.

The dirty oil tank and clean oil tank shall have a minimum storage capacity of 15mm3 each. All the tanks shall be installed in the oil room located in the Annex Bay (Unit No. 4 side).

28.7.3 Oil Pumps

28.7.3.1 Service Requirement and Characteristics

i) Two nos. pumps each of 4m3/hr. capacity at a pressure of 6.00kg/cm2 shall be provided for lubricating and governor & MIV OPU system to pump the oil in the tanks from the generator/ turbine bearing baths & OPUs of governors & MIVs. Each pump shall be self-priming for a suction lift of at least 15m. The Contractor shall check the pressure requirement of the system and shall ensure that all pumping operations are possible at a minimum temperature of 15°C. Provision in the supply header to bypass the deeding pump shall be made so that the oil can be directly fed to the bearings and OPUs of governors and MIVs.

ii) The normal operating temperature of the oil may vary between 15°C and 55°C but on rare occasions the temperature of the oil may rise up to 70°C.

28.7.3.2 General Construction

i) Each pumping set shall be a standard product of reputed manufacturer and of a design, which has been proved reliable and satisfactory in the service intended. The design and construction of each pump shall be such that it will operate satisfactorily at full load without objectionable noise or vibration.

ii) Each pump shall be electric motor driven, positive displacement rotatory type, with horizontal driving shaft direct connected to the electric motor through a flexible coupling. Each pump shall be equipped with a pressure relief or unloading device to protect the pump against excessive pressure in case of throttling in the discharge line. The relief or unloading device shall be set for a pressure, which will not overload the motor when operating at full load. Relief valve or unloading device may be built into the pump casing or may be furnished separately for mounting in the connected piping. Each Pump shall have the capacity specified at the specified pressure at a suitable speed. The specified pressure includes suction lift and friction. One pump shall be satisfactory, installed in oil room and other shall be portable type.

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iii) Each pump casing shall be accurately machined and fitted. The gears/rotors shall be of heat-treated steel or special alloy iron, of suitable composition and hardness, and shall be carefully machined and fitted. The bearings of the pump shall be properly lubricated. Each pump shall be equipped with a suitable stuffing box and packing or approved type mechanical seals.

iv) Piping connections to the pump shall be flanged, faced, and drilled or screwed with iron pipe threads.

v) Each stationery pump and its motor shall be mounted on a rigid common base plate or welded structural steel or cast iron whereas the portable pump set shall be mounted on a chassis fixed to castor wheels with maneuvering handling.

vi) Pump motor control center for fixed type pump set shall be provided with all necessary accessories, power & control cables, starters, etc. However, for the portable type, the flexible cables with plug in type connector along with all necessary accessories to be mounted on the pump frame shall be provided.

28.7.4 Centrifuge

i) The centrifuge shall be of a design to produce a high centrifugal force. It shall be sound in construction and free from any unbalanced condition and shall operate without objectionable noise or vibration. It shall be equipped with adequate bearings and lubricated to ensure easy running and long continuous service. It shall have an enclosed oil inlet and outlet with sight glasses or inspection ports and a positive means of determining when any of the oil entering the purifier is bypassing the bowl. It shall be easy to dismantle, clean and assemble and so designed as to permit quick adjustment to purify oils of different specific gravities or water content. The collecting pan and bowl housing shall be substantial in design. The centrifuge shall be completely enclosed and constructed, so that there will be practically no oxidation of oil due to contact with the atmosphere and practically no escape of oil vapour.

ii) The driving mechanism and gears shall have high efficiency, smooth and quite running with no exposed moving parts. The purifier shall be equipped with sight glasses or inspection ports to provide visual indication of the flow of both the purified oil and the separated water from the collecting pan.

iii) The material for rotating parts and bowl of centrifuge, bowel assembly shall be of high grade stainless steel, considering the purpose and the extent of contact with oil. Other wetted parts shall be of stainless steel or other corrosion resistant material confirming to applicable IS.

iv) The Contractor shall clearly state the name, composition of material used for bowl, base, cover and shaft of centrifuge.

v) The centrifuge shall be provided with self-draining arrangement and hand operated bowl-lifting device.

28.7.5 Centrifuge Pumps

i) The purifier unit shall furnish with a positive displacement feed pump and a similar type of discharge pump. The pumps shall be a standard product of an approved manufacturer, which has been proved reliable and satisfactory for the service intended. The pumps shall be electric motor driven and shall operate without objectionable noise or vibration. The control & operating system of motors shall be mounted on the body/frame of purifier. The pumps shall be helical, herringbone, or spur gear type, or the screw type.

ii) The feed pump shall have a normal capacity of at least 10 percent greater than that of the purifier unit when operating under a maximum suction lift of 5m against pressure required to feed the purifier.

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iii) The discharge pump shall have a capacity equal to the capacity of its purifying unit against a discharge pressure at the outlet of 6.00kg/cm2.

iv) Provision shall be made in the purifier to prevent the operation of its centrifuge unless the feed pump and the discharge pump are operating. Each pump shall be fitted with adequate relief/by-pass valves to prevent damage from excess pressure.

v) The Contractor shall check the pressure requirement of the system and shall ensure that all pumping operation are possible at the minimum temperature range of 15°C to 55°C and on rare occasions the temperature of the oil may rise upto 70°C.

28.7.6 Heaters

i) The automatic temperature controlled electric heaters to be furnished with each purifier shall be of the low current density type, designed so that oil will not carbonize due to high temperature at the surface of the metal surrounding the heating elements. The heaters shall have ample capacity to raise the temperature of the oil supplied, when operating at the maximum capacity of the centrifugal purifier without the aid of filter press, from normal operating temperature of the oil to the temperature, which the Contractor recommends, for purification of oil.

ii) The heater shall be suitable for operating on 3-phase, 50Hz, 415 ± 10% and so wired that the heater load will be equally divided, as nearly as possible between the three phases for all positions of the temperature control switch.

iii) All sections of the heaters shall be arranged for the oil to flow through them in series.

28.7.7 Polishing Filter

The purifier shall be equipped with a suitable size polishing filter for removing suspended light & fibrous foreign material from oil after the oil has been passed through the centrifuge.

28.7.8 Automatic Temperature Control

The temperature of the oil leaving the heater shall be automatically controlled by a thermostatic switch of the double acting, fully adjustable type. The thermostatic switch shall operate suitable magnetic controls, which shall function to open the heater circuits when the desired temperature is exceeded and to close the heater circuits before the temperature drops below the temperature necessary for proper purification of the oil. The heater circuits shall be interlocked with the pump motor circuits to shut off the heaters when the pumps are not being operated. The heater cabinet shall be equipped with inlet and outlet thermometer and a drain connection. The necessary schematic diagram is this regard shall be submitted for the approval of Purchaser.

One temperature gauge before the heater and one temperature gauge and separate temperature switch after the heater shall be provided for high temperature annunciation of oil. One temperature switch for high temperature annunciation of heater shall also be provided.

28.7.9 Flow Meter

The purifier shall be equipped with a flow meter of approved manufacture, mounted in a convenient place for registering the amount of oil purified.

28.7.10 Sampling Cocks

Sampling cocks shall be provided so that samples of dirty oil and centrifuged oil may be taken to determine the condition of the oil as it passes through each stage of purification.

28.7.11 Piping of Oil Purifier

Suitable oil resistant piping, fittings, oil receiver and valves shall be provided with each oil purifying unit so that it will operate satisfactorily as a unit. The unit shall be so arranged that it may be easily and quickly drained. The pipe shall be ERW steel pipe conforming to IS: 1209 and suitable for the working pressure of 7 kg/cm^2.

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28.7.12 Mounting

The entire oil purifying equipment shall be mounted upon a substantial metal base frame with drain connections. The portable type oil purifying system shall be mounted on a wheeled type chassis (trolley), which can be easily maneuvered from one location to another.

28.7.13 Electrical Equipment

i) All electrical control equipment and wiring on the purifier shall conform to the latest requirements of the relevant Indian or International Standards except as otherwise specified

ii) All necessary safety devices and all other devices & equipment required for proper operation of the purifier, whether or not specifically asked for in this specification shall deemed to be included in the scope of supply.

iii) A main line safety switch of suitable rating shall be provided at an easy reach from outside the purifier assembly, Protective, starting, and control equipment shall be furnished by the Contractor and shall be centralized in suitable splash proof ventilated steel cabinets neatly mounted on the purifier. All the starting and protective equipment shall include broadly as specified under:

a) Magnetic contactor of suitable current for the motors,

b) Thermal overload protection,

c) Under-voltage protection,

d) Start-stop push button in splash proof box,

e) Such interlocks as required to protect adequately the entire unit from trouble due to failure in the operation of any integral part.

iv) All cables i.e. power & control cables required for satisfactory operation of the system as described in the technical specifications shall be included in the scope of supply. The cables shall be of sufficient size and suitable for continuous operation under climatic conditions prevailing at project site. All AC power cables shall be XLPE/HR-PVC insulated, 1100V grade FRLS, multi/single core aluminum stranded conductor. All control cables shall be HR-PVC Insulation, 650/1100V grade, FRLS, multi core annealed high conductivity copper conductor, PVC sheathed conforming to IS: 1554 (Part I/II). The outer sheath shall be specially formulated PVC compound. All control cables shall have at least 20% or 1 spare core whichever is more.

v) All the power & control cables for the equipment shall be laid & terminated by the supplier. Suitable lugs/terminal blocks shall be provided in the various panels/equipment for termination. The power & control cables shall be laid in neat & logical manner on cable trays/racks/conduits. The cable trays/racks/conduits along with necessary fittings, supports etc. shall be included in the scope of supply. All movable units shall be provided with at least 20m flexible power cable for connections to the power supply device. The power cables for the fixed pumping units shall be provided for connecting in the power supply point/receptacle to be provided in the lubricating oil plant room.

28.7.14 Pipes, Fittings and Hoses

The necessary piping, valves and fittings given in the schedule of requirements shall be supplied. All pipes used in the oil handling system shall be made of Stainless steel conforming to latest version (ANSI B36.19). All fittings shall conform to ASME B16.9. The quantities of pipes, valves, quick end couplings etc. indicated in the schedule of requirement are tentative and the same shall be finalised during detailed design and engineering stage. In case the quantities of these items (for which unit rates have been indicated in the Price Schedules) increase or decrease during the design and engineering stage, the ex-Works contract price for these items including, transportation, insurance, storage and preservation, erection and commissioning shall be increased or decreased on pro-rate basis accordingly. However, for the

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evaluation of bids, the quantities of these items as specified in the schedule of requirements/price schedules shall be considered.

The pipe line system shall be equipped with pressure gauges. The piping shall be supplied complete with requisite fittings, valves, test, air release and drainage plugs or cocks and other necessary instrumentation and devices to provide desired function and operation with ease, flexibility and easy maintenance. All valves shall be of cast steel suitable for working pressure as indicated for each individual oil handling system. Suitable support system for the piping and valves comprising hangers, brackets, hooks, pedestal, etc., shall be designed and provided. Pipelines may undergo expansion or contraction under service conditions and adequate allowance shall be made for the same. All items of pipelines shall be thoroughly cleaned individually before installation and after erection, in stages/completion, using proper method. It shall be ensured that they are perfectly clean inside before putting into use. The layout shall be such that valves, gauges/indicating instruments, are conveniently located to enable easy access for operation and reading. The requisite piping shall be provided in the ducts or the openings in the floors, walls or ceiling as required. The layout shall be such as would not interfere with movement of operation and maintenance personnel. The support system shall be rigid enough to prevent piping vibration when in operation. Each valve shall have a valve number, suitably fitted to it and a same plate indicating the function of the valve. The gaskets shall be of requisite material and thickness to suit service conditions. The pipe shall be designed for a working pressure of 7 kg/cm^2.

The Contractor shall provide valve boxes of cabinet type at suitable locations for connecting flexible hose with proper oil leakage unit and drainage facilities. These shall be used to connect the system to the equipment for the purpose of filling/draining operations.

28.7.15 Hose and Hose Coupling

The inlet and outlet of all portable oil pumps and purifier pumps shall be provided with oil resistant galvanized steel lined hoses in suitable lengths. Suitable hose couplings for connections to the steel oils shall also be included in the offer. Alternatively, flexible hose, wire lined & having a special rubber lining complete with coupling arrangement may be provided. The flexible wire lined hoses shall be of oil resistant material and reeled on a reeling drum, which shall be mounted on the wall adjoining to each valve cabinet location. The length of each hose shall be 15m.

28.7.16 Electric Motor

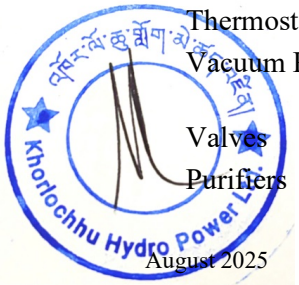
Each motor shall be squirrel cage, 415V, 3-phase, 50Hz, constant speed, splash proof type with Class “F” insulation and conforming to IS. 325 (latest version). The selected rating of each motor shall have adequate capacity for stationary operation, which the driven unit may impose with a temperature rise not exceeding 60°C above an ambient temperature of 35°C at continuous full load operation.

Each motor shall be designed for full voltage starting, low starting current and normal starting torque.

28.7.17 Equipment Makes

The major equipment of oil handling and purification system shall preferably be of following make (s). Equipment of any other make having equivalent or better quality shall be specifically brought out in the deviations statement of the bid and shall subject to acceptance of the purchaser.

Gear Pump	: Rotodel/ Tushaco/ Airoto
Thermostats	: Indfoss/ Jumo Vasutech
Vacuum Pumps	: Shinko Seiki (Japan)/ Leybold(Germany)/ Dicon Product(India)
Valves	: Audci/ Arkey/ BDK
Purifiers	: Alfa Level/ West Falio/ Fowler Westrup/ VPIL



Gear Pump		: Rotodel/ Tushaco/ Airoto
Cables		: Finolex/ Asian/ Polycab/ Incab/ Unistar
Contactors/Relays Switchgear	&	: Siemens/ Telemechanique/ ABB/ L&T/ Alstom

28.7.18 Auxiliary Power Supply

The equipment offered shall be suitable for operation on the following supply system;

i) 451V, 3-phase, 4-wire, 50Hz, AC for power

ii) 220V, 2-wire DC for Control protection and alarm

The above supply voltage and frequency may vary as follows

AC voltage	=	: ± 10%
Frequency	=	: ± 3%
Voltage & frequency	=	: Any combination of above
DC voltage	=	: Between 187 & 242 (both inclusive)

The purchaser shall provide AC & DC supplies from the AC and DC distribution panels located in the machine hall & the transformer hall. Further, distribution of AC/DC supply, wherever required for operation of the equipment covered in the technical specifications shall be the responsibility of the supplier.

28.7.19 Painting

The whole of the equipment and piping, except bright parts and such portions as are finished in enamel, shall be painted with two priming coats of approved rust resistant paints in plain colour before packing and the parts not so painted shall be protected against deterioration during shipment. Unless otherwise stated, approval shall be obtained from the Purchaser for the type and colour of paint to be used. After erection at site, every painted part shall be cleaned, filed and shall be given two coats of suitable oil paint of approved colour.

The inside surface of each oil storage tank shall be sand blasted and painted with suitable rust proof enamel, of the oil-resistant type.

All painting material required for use after the erection at site shall be supplied by the supplier along with the equipment.

28.8 Inspection and Tests

28.8.1 Tests at Manufacturer's Works

All equipment, including oil purifiers, pumps, vacuum unit and their motors covered under this specification shall be tested in accordance with applicable IEC/Indian Standards at the manufacturer's works and four copies of test certificates shall be furnished to the purchaser to prove that the equipment supplied meets the requirements of the these standards or these specifications, whichever are more stringent.

The supplier shall carry out all important tests/inspection in the presence of Purchaser or his authorized representative. The tests to be witnessed by the purchaser shall be finalised during detailed design stage. A minimum of one month of notice in advance shall be given to the Purchaser to enable him to be present during testing.

28.8.2 Tests at Site

Before final acceptance by the Purchaser of the work completed by the supplier all equipment and piping etc. shall be hydraulically tested at 1.5 times system design pressure by the supplier as directed by the Purchaser or his authorized representative. Such tests shall demonstrate the compliance of the equipment and piping, etc. with the requirements of the specifications.

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The equipment that fails to meet the test requirements shall be corrected within one month and tested again for satisfactory results as per requirement of these specifications.

All facilities, instruments, equipment and manpower required to make the tests shall be arranged by the supplier without any additional cost to the purchaser.

Successful completion of the final acceptance tests shall be a condition prevalent to a final acceptance certificate in support of the equipment.

28.9 Quality Control and Assurance

The Contractor shall submit detailed Quality Assurance Plan and Inspection Schedule for Employer's review and approval in accordance to clause 12 of General Technical Specification.

28.10 Drawings, Documents and Design Calculations

28.10.1 Design Memorandum

The Contractor shall submit to Employer a design memorandum prepared in accordance to clause 2.5 "Design Memorandum", of General Technical Specification.

28.10.2 Drawings and Documents

The Contractor shall submit all the drawings and documents in accordance with requirements stipulated in clause 2.6 "Drawings & Documents to be supplied by Bidder" of General Technical Specification.

These drawings and documents shall include at least the following:

i) Schematic drawings of the oil handling plant with all piping systems, control systems and instrumentation with reference of the relevant Indian/international standards followed for the design and construction of the plant and its components/material,

ii) General arrangement plan, chapter of main and sub-assemblies with detailed dimensions of the parts and the size of each and every part of the equipment to be supplied under this specification,

iii) Complete list of accessories and auxiliaries with their make and accompanied with catalogue/pamphlets/literature/write-ups,

iv) Complete list of instruments offered with their make and accompanied with catalogue/pamphlets/literature/write-ups.

28.10.3 Design Calculation

The Contractor shall submit the design calculation in accordance to clause 2.6.4 "Design Calculations" of General Technical Specifications, Volume-4 covering at least the following, for review/ acceptance:

i) Calculation for selecting the pumping capacity of the pumps including vacuum pumps, oil tank and plant capacity (in case of higher capacity, the same shall be supplied),

ii) Methods/ principal adopted for determination of oil characteristics,

iii) Capacity of the heater for lubricating oil handling system,

iv) Total power requirement individually for the lubricating oil purifying system and of oil transfer pumps.

v) The Contractor shall also provide other calculations as required by the Employer for his approval of the Contractor's design.

28.11 Delivery, Installation and Commissioning

The Contractor shall follow the general requirement of Delivery, Installation and commissioning as per relevant clauses in General Technical Specification.

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28.11.1 Specific Packaging, Handling and Storage Requirements

Prior to shipping, all threaded openings shall be closed with standard pipe plugs. Flanged openings shall be protected with blind flanges with gaskets bolted in position.

28.12 Schedule of Requirement

The scope of supplies and services shall be as per various clauses of the technical specifications and supplier shall be responsible to ensure completeness of supplies and services even if these are not fully covered under this clause.

The broad schedule of requirements is given as under:

Sl.No.	Description	Quantity
1	Lubricating Oil storage tanks of capacity not less than 15 m^3 (approx. size 2.5m dia. x 3.0m height) for lubricating oil, cylindrical welded plate steel construction, vertically supported, complete with man holes, air vents, overflow, oil level gauges, foundations, inserts etc. as described in the specifications.	2 Nos.
2	Oil pumps for lubrication oil capable of delivering oil at the discharge rate of 4m3/hr & at a pressure of 6.0kg/cm2 and against a suction head of about 15m, complete with motor, motor control, pressure gauge, filter, relief devices and other accessories essential for satisfactory operation.	2 Nos. (1 Stationery & 1 portable)
3	Lubricating oil purifiers of capacity 4m3hr complete with centrifuge, oil pump with motor, motor control, heaters & heater control, thermostats, controls, protection, gauges, piping and valves and other accessories required for satisfactory operation.	2 Nos. (1 Stationery & 1 portable)
4	Barrel pumps of capacity not less than 0.5 litres/sec.	2 Nos.
5	Valve cabinets for lube oil with glass	4 Nos.
6	Wall/Column mounted oil resistant hose cabinets	2 Nos.
7	Oil resistant steel lined hose pipe fitted with quick connect coupling at both ends (male ends) DN-50mm	2 Nos.
8	Plug valves, carbon steel (inside screwed type), DN=50mm	25 Nos.
9	Non-Return valve, DN=50 mm	4 Nos.
10	Quick connect coupling, 2-ways sealing type (female end) with nipple for fitting with valve / pump	55 Nos.
11	ERW Carbon steel pipe (DB-50 mm) with necessary pipe flanges, fasteners, tees, elbows and other fittings	450m
12	Strainers, 50 microns	1 No.
13	Power & Control Cables including Cables Trays/Racks/Conduits, Supports, Fittings, Embedment etc., required for Oil Handling & Purification System	1 Lot
14	Mandatory Spares as described in the technical Specifications	Lot
15	Tools and Instruments as described in the technical specification	Lot
16	Any other items not mentioned above but required for completeness of the system,	Lot

Any item of supply not explicitly listed but otherwise either implied by the contents of the specification or essential for smooth operation of the equipment shall be construed as forming part of the supply and no additional charges shall be payable for the same.

As and when any particular item/s which was not explicitly listed are found to be essential, the contractor shall affirm the inclusion of the same in the scope of supply without any extra charge.

28.13 Spare Parts

Recommended spare parts shall be supplied in accordance to clause 3 "Spare Parts and Tools" of General Technical Specifications. Specified spare parts to be supplied under this Chapter are as follows.

Sl.No.	Description	Quantity
1	Connecting hose with couplings of each type and size	2 nos. of standard lengths of each type
2	Oil pump of all type	1 no. of each type
3	Vacuum pump of all type	1 no. of each type
4	Complete set of seals and gaskets for the system	One (1) set comprising of each of these items)
5	Complete set of filters for the system	One (1) set comprising of each of these items)
6	Complete set of valves for the system	One (1) set comprising of each of these items)
7	Instrument (Pressure/ Vacuum gauges, Level indicators)	1 no. of each type used
8	Heating Element	Five nos. of each type used

Besides above, the Contractor shall recommend any additional spare parts, which in his opinion are necessary for satisfactory operation of the system. However, the procurement of these recommended spares shall be at the discretion of the purchaser. The additional recommended spare parts shall be indicated in the Data Sheets of Volume-6.

28.14 Guaranteed & Other Technical Particulars

The Contractor shall furnish the Guaranteed & Other Technical Particular requirements specified separately in Data Sheets of Volume-6

28.15 Tools and Instruments

The Contractor shall supply all necessary tools and Instruments etc. for installation, repair and maintenance in accordance to clause 3.2 "Tools and Instrument" of General Technical Specification.

28.15.1 Special Tools

The Contractor shall list and supply all special tools. List of such tools including their make and detailed specification, shall be submitted for acceptance by the Employer.

28.16 Quality Assurance & Testing

The Contractor shall submit detailed Quality Assurance Plan and Inspection Schedule for Employer's review and approval in accordance with clause 12 of General Technical Specification.

28.17 Deputation of Engineers for witness of Tests, Inspection & Training

The Employer's representatives shall be deputed for the following purposes.

1	Inspection and testing of BFVs and Accessories	Employer's representatives from time to time
2	Training at the plant and design office	2 Engineers for five days (1 round trip)

The training of employer's personnel shall be as specified in clause 11.0 "Training of Employer's Personnel" of General Technical Specification.

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28.18 Deviations from Specifications

All deviations from these specifications shall be separately listed in the requisite Performa of the bid document, in the absence of which, it will be presumed that the provisions of the specifications are fully complied with by the bidder. However, the deviations, which are better than the specifications shall be considered by the purchaser.

28.19 Completeness of Contract

Any fittings, accessories or apparatus required for successful commissioning though may not have specifically mentioned in the specification but are usually necessary for the completeness of the works shall be deemed to be included in the specification and shall be supplied by the bidder without any extra cost to the purchaser.

CHAPTER 29: WORKSHOP EQUIPMENT

29.1 Workshop Equipment

The scope of supply by the Supplier shall include, but not be limited to the following:

29.1.1 Mechanical Workshop Equipment

1 1 No Column type drilling Machine with stepless variable speed drive, coolant supply and accessories.

2 1 No engine Lathe

3 1 No Power Hacksaw with two speed operation including working lamp and coolant supply.

4 1 No Pedestal tool grinding machine.

5 1 No Universal knee type milling machine.

6 1 No Single pulley type shaping machine.

7 1 No Toggle action shear

8 1 No Gas welding equipment

9 2 No Arc welding machine

10 3 No Portable drilling machine

11 1 set of basic tools

12 2 Nos Portable electric grinders

13 2 no's Portable toolboxes with basic tool kit

14 1 No tool trolley with basic tool kit

15 8 Nos Hydraulic Jack

16 2nos tackling block with capacity of 30kN

17 4 no's tool cabinet

18 2 No work bench

19 1 No Marking plate

20 1 No Levelling Plate

21 1 No Bearing Puller (Three arms)

22 1 No Hydraulic press machine

23 2 Nos of Portable welding (Arc + TIG)

24 1 No of Pipe Bending machine (Portable)

25 1 No of Tube Bending machine (Fix)

26 4 no of Bench vice

27 2 No of Pipe Vice

28 2 No of Shadow boards for tool storage

29 2 Nos of Gas cutting set

30 2 Nos of Battery-operated portable grinders

31 2 Nos of Battery-operated portable drill machines

32 Jig Saw Machine

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33 Chop Saw

34 1 No High-pressure washer

35 4 Nos of Dewatering pumps with flex hose & starter

36 Electric impact wrench

37 Magnetic Drill Machine

38 4 Nos of Chain blocks- 1T

39 4 Nos of Chain blocks- 2T

40 2 Nos of Chain blocks- 5T

41 Hoist 10T system

42 Hydraulic nut splitter

29.1.2 Laboratory Equipment

1 1 No. Air treatment and smoke extraction equipment

2 4 Nos. Boards for the storage of test and measurement devices

3 2 Nos. Flow meter tanks

4 1 Set of Water distilling apparatus

29.1.3 I&C Laboratory Equipment

1 4 Nos Portable digital multi meter (4 ½ digit)

2 2 No Test manometer

3 1 No Master Pressure Gauge

4 1No Integrated Calibrator Electronic & Pneumatic Instruments (PORTABLE)

5 1 No Precision Set Thermometers (MERCURY IN GLASS)

6 1 No Temperature Calibrator (Portable)

7 1 No Barometer

8 1 No Wet & Dry Bulb Hygrometer

9 2 No Test RTD

10 1 No mA & mV Calibrator (Portable)

11 1 No Multifunction Calibrator

12 1 No High-Resolution Timer/Count

13 1 No DC Regulated Power Supply

14 1 No Adjustable AC Power supply

15 3 No Digital Tong Tester

16 1 No Single-Phase Auto Transformer

17 2 No Insulation Tester (Megger)

18 1 No Sound Level Monitor

19 1 No AC Power Meter

20 1 No Vacuum tester

21 1 No Digital Tachometer

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22 1 No Potentiometer/ Rheostat

23 2 No Digital Stopwatch

24 1 set Furniture

25 1 No Phase Sequence meter

26 1 No. Portable Moisture meter

27 1 Nos. Earth resistance tester (Four terminals)

28 1 No. Portable Moisture meter

29 1 No. Portable light intensity meter (Lux meter)

30 1 No. Thermal Image camera (Portable)

31 Portable Supply boards

32 Portable lights

- Supplier to provide all drawings and details of machines (Manuals)
- Supplier to provide Chemical tests reports of all the materials used in Workshop machine components
- Vendor to provide civil drawings and layout of machine installation.
- Performance test at site and at vendor's works need to be mentioned.

29.2 Terminal Point of Supply & Services

29.2.1 Terminal point for Supplier's equipment scope of supply are as follows:

i) Terminal point of Mechanical works:

TP.NO	ITEM	DESCRIPTION	REMARKS
M1	EQUIPMENT FOUNDATION	At the bottom of base plates. The Bidder shall supply the sole plates, sub-sole plates, shims, wedges, foundation bolts / nuts / washers, templates, all necessary steel parts to be embedded in the concrete works.	The grouting and concrete foundation will be by the Purchaser.

ii) Terminal point of Electrical works: At terminals of Bidder's equipment.

29.3 Performance Test

Performance test shall be for following:

29.3.1 Lathe

i) Check for Accuracy of the machine.

ii) Check for working of Lubrication system & coolant system.

iii) Trouble free smooth operation.

iv) Satisfactory operation of controls & limit switches

v) Check for vibration of lathe.

vi) Safety interlock of simultaneous engagements i.e. feed & thread

29.3.2 Milling / Shaping Machine

i) Check for Accuracy of the machine.

ii) Check for working of Lubrication system & coolant pump.

iii) Trouble free smooth operation.

iv) Satisfactory operation of controls & limit switches

v) Check for vibration of machine.

vi) Safety interlocks of simultaneous engagements.

29.3.3 Balancing Machine

i) Check for Accuracy of the machine.

ii) Check for working of Lubrication system & coolant pump.

iii) Trouble free smooth operation.

iv) Satisfactory operation of controls & limit switches

v) Check for vibration.

vi) Safety interlocks of simultaneous engagements.

29.3.4 Grinding Machine

i) Check for Accuracy of the machine.

ii) Check for working of Lubrication system & coolant pump.

iii) Trouble free smooth operation.

iv) Satisfactory operation of controls & limit switches

v) Check for vibration of grinding machine.

29.3.5 Drilling Machine

i) Check for Accuracy of the machine.

ii) Check for working of Lubrication system & coolant pump.

iii) Trouble free smooth operation.

iv) Satisfactory operation of controls & limit switches

v) Check for vibration.

29.3.6 Welding Equipment

i) Check for Accuracy of the machine.

ii) Trouble free smooth operation.

iii) Satisfactory operation of controls & limit switches

iv) Check for vibration.

- **Note:**

i) All tests to be conducted with full load.

ii) Erection platform and erection crane to be removed before conducting tests.

iii) Any other relevant tests as desired by Purchaser/Consultant shall be demonstrated by the Bidder.

29.4 Employer's Specification of Workshop Equipment

Sl. No.	Item	Unit	Requirement
	Mechanical Workshop equipment		
1	**Engine Lathe**		
1.1	**Capacity**		
1.2	Quantity	No	1
1.3	Centre distance	mm	1500
1.4	Swing over bed	mm	500
2	**Column type drilling machine**		
2.1	Quantity	No	1
2.2	Working radius	mm	400
2.3	Capacity	mm (in steel)	40
2.4	Spindle travel	mm	180
2.5	Variable speed		Required
3	**Power Hacksaw**		
3.1	Quantity	No	1
3.2	Sawing Capacity	mm dia	300
3.3	Two Speed Operation		Required
4	**Pedestal Tool Grinding Machine**		
4.1	Quantity	No	1
4.2	No of grinding wheels	Nos	2
4.3	Dia of grinding wheel	mm	150
5	**Universal Knee type milling machine**		
5.1	Quantity	No	1
6	**Single Pulley Shaping machine**		
6.1	Quantity	No	1
6.2	Stroke	mm	500
7	**Toggle action shears** (Cutting 6 mm flat steel and 13 mm dia steel bar)		
7.1	Quantity	No	1
7.2	Knife length	mm	200
8	**Gas Welding Equipment with gas bottle tray**		
8.1	Quantity	No	1
9	**Arc welding machine**		
9.1	Quantity	No	2
9.2	Electrode Dia (Max)	mm	8
9.3	Accessories		Required
10	**Portable Drilling machine**		

Sl. No.	Item	Unit	Requirement
10.1	Quantity	No	1
11	**Basic Tools**		
11.1	Quantity	No	1
12	**Portable electric grinder**		
12.1	Quantity	Nos.	2
13	**Tool Trolley with basic tool kit**		
13.1	Quantity	No	1
14	**Hydraulic Jack**		
14.1	Quantity	Nos.	4
14.2	Capacity	KN	250
14.3	Quantity	Nos.	4
14.4	Capacity	KN	100
15	**Tackling Block**		
15.1	a)Quantity	Nos.	2
15.2	b)Capacity	KN	30
16	**Tool Cabinet**		
16.1	Quantity	No	4
17	**Work Bench**		
17.1	Quantity	No	4
18	**Marking Plate**		
18.1	Quantity	No	1
19	**Levelling Plate**		
19.1	Quantity	No	1
20	Portable Toolboxes with basic tool kit	No	3
21	**Instrumentation Lab Equipment**		
21.1	**Portable Digital Multimeter (4 ½ Digit)**		
i)	Quantity		4 set
ii)	Make & Model No		(should be preferably Industrial duty Fluke or equivalent)
iii)	Ranges & Accuracy		DC voltage: 0 - 200 mV / 1000 V with accuracy 0.05%
			AC voltage: 0 - 200 mV / 750 V with min. accuracy +/- 0.1%
			DC current: 0 - 200 mA / 2A with accuracy 0.5%
			AC current: 0 - 200 mA/ 2A with accuracy 0.5 %
			Resistance: 0 - 200 Ohm / 20 M Ohm with accuracy 0.2 %
			Frequency: 10 Hz to 100 kHz with accuracy with accuracy 0.01%

Sl. No.	Item	Unit	Requirement
iv)	Features		- 6 functions: DC Volts, AC Volts, DC mA, AC mA, frequency and Ohms – Total 25 ranges (min.)
			- Battery / Mains operation with low battery voltage indicator (9 V single battery)
			- Battery life 150 hours (min.)
			- Automatic Polarity, auto zero, auto ranging
			- Response time less than 5 seconds
			- True R.M.S display for A.C. ranges
			- Overload protection up to 1000 V D.C. or A.C. p to p.
			- Serial interface shall be RS 232 / Ethernet.
			- Data logging facility.
v)	Power Supply		Battery powered
vi)	Accessories		Test Leads
21.2	**Test Manometer**		
i)	Quantity		2 nos.
ii)	Make & Model No		*
iii)	Range		0-100 mmwc
iv)	Scale		White background with black markings
v)	Material of Construction		Borosilicate glass with MS/Aluminium cover on three sides and transparent cover on one side.
vi)	Features		Zero adjustment facility, Drain plug, Filling plug
vii)	Accuracy		± 0.1 % of full scale **or better**
viii)	End Connection		*
ix)	Accessories		- Filling liquid 1 bottle
			- Funnel
			- Mounting stand
			- Five valve manifold
			- Aspirator
21.3	**Master Pressure Gauge**		
i)	Quantity		4 nos.
ii)	Make & Model No		*
iii)	Range		-1 to 0,0-2,0-10,0-25, kg/cm2
iv)	Dial Size		250 mm

Sl. No.	Item	Unit	Requirement
v)	Material		Bourdon :SS316
			Movement:SS304
			Shank:SS316
vi)	Features		Anti Parallax mirror dial
vii)	Accuracy		± 0.1 % of full scale **or better**
viii)	End Connection		*
ix)	Pointer		Knife edge micrometer adjustable pointer
21.4	**Integrated Calibrator –Electronic & Pneumatic Instruments (Portable)**		
i)	Quantity		1 no.
ii)	Make & Model No		*
iii)	Range		a) DP transmitters, Draft Gauge, DP Indicators: -2000 mmWC to +2000 mmWC
			b) DP transmitters, Draft Gauge, DP Indicators, Pressure Transmitters: -0.8 kg/cm2 to +10 kg/cm2,
			c) Pressure Gauges, Pressure switches, Pressure Transmitters: 0-350 kg/cm2
			d) I/P & P/I Converters, DP Pressure Transmitters 0-20mA/(-)200mV
iv)	Display		4 ½ digit LCD with use seletable pressure units
v)	Features		Mesurement and Simulation
vi)	Accuracy		± 0.025 % of full scale
			+/- 0.01mA
			+/- 0.01mV
vii)	Accessories		- Carry Strap
			- High Pressure pump upto 350 kg/cm2
			- Hand operated vacuum pump
			- Test leads
			- Rechargeable Battery and Battery charger
21.5	**Precision Set Thermometers (Mercury In Glass)**		
i)	Quantity		1 no each range
ii)	Make & Model No		*
iii)	Ranges		(-) 38 to 2 Dec C
			(-) 8 to 32 Dec C
			25 to 55 Dec C
			50 to 80 Dec C
			75 to105 Dec C
			95 to155 Dec C

Sl. No.	Item	Unit	Requirement
			145 to 205 Dec C
			195 to 305 Dec C
			295 to 405 Dec C
iv)	Accessories		Ice point auxiliary scale cushioned carrying case
21.6	**Temperature Calibrator (Portable)**		
i)	Quantity		1 no.
ii)	Type		Microprocessor based
iii)	Features		- Programmable for different temperatures and slope rates suitable for RTDs, thermocouples, switches etc.
			- Self diagnostic capability
			- Low battery indication
iv)	Ranges, resolution ,accuracy & stability		-50 to 123 Dec C at 0.1 Dec C resolution, +/- 0.3 Dec C accuracy, +/- 0.05 Dec C stability
			50 to 650 Dec C at 0.1 Dec C resolution, +/- 0.5 Dec C accuracy+/- 0.05 Dec C stability
			200 to 1204 Dec C at 1 Dec C resolution, +/- 2 Dec C accuracy+/- 0.5 Dec C stability
v)	Display		41/2 digit displays
vi)	Accessories		Calibration software, RS-232C interface
21.7	**Barometer**		
i)	Quantity		1 no
ii)	Make & Model No		*
iii)	Range		508 to 794 mm Hg
iv)	Accuracy		+/- 0.1% FSD or better
21.8	**Wet & Dry Bulb Hygrometer**		
i)	Quantity		1 no
ii)	Make & Model No		*
iii)	Range		Humidity: 0-95%
			Temperature (-) 20 to 60 Dec C
iv)	Features		Wet & Dry calibration adjustments
v)	Accuracy		Humidity: +/- 3%
			Temperature: +/- 0.8 Dec C
vi)	Resolution		Humidity: +/- 0.1%
			Temperature: +/- 0.1 Dec C
21.9	**Ultrasonic Flow meter (Portable)**		
i)	Quantity		1 no.
ii)	Make & Model No		*

Sl. No.	Item	Unit	Requirement
iii)	Type		Dual transmitting/receiving clamp-on also for large pipes
iv)	Range		*
v)	Pipe size in mm		50 mm to 3000 mm
vi)	Operating temperature		(-) 20 Dec C to 125 Dec C
vii)	Output		4-20mA DC
viii)	Display		Backlit LCD/LED
21.1	**Test RTD**		
i)	Quantity		2 nos.
ii)	Make & Model No		*
iii)	Range		Upto 350 Dec C
iv)	Type		Pt100, Simplex , 3-wire
v)	Insulation resistance		>500 Mohm at 500 VDC
vi)	Sheat Material		SS316
vii)	Sheat dimesnsions		Suitable for calibrator
viii)	Others		Extension wires with Teflon isolation 3 meters long SS wire braided cable
ix)	Accuracy:		Class-A as per IEC60751
21.11	**mA & mV Calibrator (Portable)**		
i)	Quantity		1 no.
ii)	Make & Model No:		*
iii)	Accuracy		0.02%
iv)	Range		0-24 mA
			0-200mV
			0-24V
v)	Features		- Source /measure of current and voltage
			- Step and linear rampout function
			- Configurable zero and span settings
vii)	Display		4 1/2 LCD digit display
viii)	Accessories		- Trasnportation wrist strap
			- Battery with charger
21.12	**Multifunction Calibrator**		
i)	Quantity		1 no.
ii)	Make & Model No		*
iii)	Type		Microprocessor based suitable for measurement of transmitters, RTDs, T/Cs,
iv)	Features		- Source for Calibration of secondary instruments and system inputs



Sl. No.	Item	Unit	Requirement
			- Data entry through numeric function keys
			- Built in diagnostics and auto calibration facility
			- Capable of measuring of voltage, current, mv, RTD, frequency and simulation of corresponding primaries including 2 wire transmitters
v)	Display		41/2 LCD digit display
vi)	Power supply		230VAC, 50 Hz, 1-phase
vii)	Accessories		- Battery with battery charge
			- Others as required
21.13	**High Resolution Timer/Count**		
i)	Quantity		1 no.
ii)	Make & Model No		*
	Features		Measurement of Frequency, Period, Frequency ratio, Totalise pulses, time interval and RPM
iii)	Range		Frequency :0.1 Hz to 120MHz with accuracy +/- 1
iv)	Period		8 ns to 200,000,000 sec
v)	Power supply		230VAC, 50 Hz, 1-phase
21.14	**DC Regulated Power Supply**		
i)	Quantity		1 no.
ii)	Make & Model No		*
iii)	Output DC voltage		0-48 V
iv)	Output current		0-10 Amps
v)	Protection		Overload & short ckt protection
vi)	Regulation		Line regulation of +/- 0.05% for 10% change in mains voltage
			Load regualtion of +/- 0.05%
vii)	Features		- 1 MV rms noise ripple
			- Volt-current analog display
21.15	**Adjustable AC Power supply**		
i)	Quantity		1 no
ii)	Make & Model No		*
iii)	Type		- Continously variable voltage auto transformer
			- Single Phase

Sl. No.	Item	Unit	Requirement
			- Floor/Table mounted, Air-cooled with enclosure
iv)	Maximum output current		10 Amps
v)	Output voltage		0-240VAC, power of 1300VA
vii)	Power supply		230VAC , 50HZ, 1-phase
21.16	**Digital Tong Tester**		
i)	Quantity		3 Nos
ii)	Make & Model No		Preferably Industrial duty Fluke or equivalent
iii)	Features		- Non-contact IR thermometer measurement
			- True RMS
			- Auto ranging
			- Auto Power off
			- 41/2 digit LCD display
iv)	Range & Accuracy		AC Current : 0.1 to 1000 A, +/- 1.2 %
			AC Voltage : 0.1mV to 600, +/- 1.0%
			Resistance: 0.1 ohm to 2000 ohms, +/- 0.7%
v)	Accessories		Test leads
21.17	**Single Phase Auto Transformer**		
i)	Quantity		1 no.
ii)	Make & Model No		*
iii)	Type		Continuously variable voltage auto transformer
			Single phase
			Floor/Table mounting, air cooled with enclosure
iv)	Rated current		20 Amps
v)	Maximum output current		30 Amps
vi)	Power supply		230VAC , 50HZ, 1-phase
vii)	Output voltage		0-270 VAC
21.18	**Insulation Tester (Megger)**		
i)	Quantity		2 nos + 2 Nos
ii)	Make & Model No		Preferably Megger Make
iii)	Range		Up to 100 Mega ohms at 1000 V (2 Nos)
			Up to 5000 V, 1 TOhm (1 No.)
			Up to 10000 V, 1 TOhm (1 No.)
iv)	Display		4 ½ digit LCD
v)	Accessories		Test leads

Sl. No.	Item	Unit	Requirement
21.19	**Sound Level Monitor**		
i)	Quantity		1 nos.
ii)	Make & Model No		*
iii)	Range		35 to 130 dB
iv)	Accuracy		+/- 1.5 dB
v)	Features		- Fast and Slow response
			- Max Hold
			- Hi and lo range selection
vi)	Frequency range		20-8 KHz
vii)	Display		41/2 digit LCD display
viii)	Accessories		As required
21.2	**AC Power Meter**		
i)	Quantity		1 nos.
ii)	Make & Model No		*
iii)	Range		AC Voltage : 0.00- 999.9 V
			DC Voltage : 0.00- 999.9 V
			DC Current: 0.00 -599.9 A
			AC Current: 0.10 A- 599.9 A
			Frequency: 20.00 Hz – 9.999 kHz
iv)	Features		- High Performance instrument for measuring AC and DC power
			- Power factor measurement
			- Harmonic analysis
			- Capable of measuring AC and DC circuit power
v)	Display		41/2 digit LCD display
vi)	Accessories		- Test Leads
			- Carry case
			- Others as required
21.21	**Digital Tachometer**		
i)	Quantity		1 set
ii)	Make & Model No		*
iii)	Type		Microprocessor based
iv)	Range		- Contact mode: 10 to 25000 RPM
			- Non-Contact mode: 10 to 99999 RPM
			- Surface speed: 6 to 100 mtr/min
v)	Features		Dry bath suitable for calibrating RTDs and thermocouple
vi)	Accuracy		0.05%
vii)	Resolution		0.1 RPM
viii)	Distance in non-contact mode		Upto 1-25 inches from Target

Sl. No.	Item	Unit	Requirement
x)	Display		41/2 digit LCD display
xi)	Power		Battery powered
xii)	Accessories		- Reflective tape (100 strips)
			- Carrying case
			- Contact adaptor
			- Surface speed wheel
			- Interchangeable tips-concave
			- Convex
			- Batteries
21.22	**Potentiometer/ Rheostat**		
i)	Quantity		1 no for each of the range indicated
ii)	Make & Model No		*
iii)	Type		Wire wound continuously variable
iv)	Range		12A/3W
			5A/18A
			2A/47W
			2A/100A
			1A/470W
v)	Features		- Single Hexangonal steel tube
			- Micanite caps for insulation on both ends
			- Polished slide rod
			- Sliding part & brush rated to withstand flowing current
			- Insulation resistance > 5 M ohms at 500 V DC between terminal and case
21.23	**Digital Stopwatch**		
i)	Quantity		2 nos.
ii)	Make & Model No		*
iii)	Modes		Split, Lap, Net time, Normal time
iv)	Accuracy		± 0.01%
v)	Resolution		0.01 second
vi)	Display Range		9 hrs 59 minutes 59.99 second
vii)	Power		Battery operated
viii)	Accessories		Carrying case
21.24	**Furniture**		
i)	Required furniture consisting of table, desk, chairs, almirah, rack etc. shall be provided to set up laboratory. Same shall be completely erected by bidder. Furniture shall include but not limited to the following:		
a)	Worktable		3 nos. of MDF board furniture table with dimensions 2000

Sl. No.	Item	Unit	Requirement
			mm (L) X 1000 mm (W) X 800 mm (H).
b)	Desk		Two numbers of glass top with MDF board table with lockable drawer at two side and sliding drawer at middle with dimensions 1200 mm (W) X 800 mm (D) X 750 mm (H).
c)	Chairs		6nos. of industrial grade swivel chairs with armrest and cushioning.
d)	Almirah		5Nos. of SS almirah with dimensions 2000 mm (H) X 800 mm (W) X 600 mm (D)
e)	Instruments Shelf (Slotted angle rack)		1 no. of RAL 7030 painted MS rack with dimensions 2000 mm (H) X 900 mm (W) X 450 mm (D).
22	**Portable Moisture meter**		
22.1	Quantity		1 No
22.2	Make		*
22.3	Type		Portable instrument for field measurement of moisture content in oil (mineral / synthetic). The display shall be in micrograms / milligrams / ppm percent of water.
22.4	Range		10 micrograms to 10 milligrams of water
22.5	Sensitivity		10 micrograms or 1% whichever is more
23	**Earth resistance tester (Four terminals)**		
23.1	Quantity		1 No
23.2	Make		*
23.3	Type		Portable instrument with test spikes for measurement of earth resistance
			Earth resistance 0.01-300ohms in multi ranges measurement range
23.4	Accuracy		± 1% οφ ρανγε ιν υσε.
23.5	Ambient temperature		0-40°C range
24	**Portable light intensity meter (Lux meter)**		Power source in built hand cranked AC Generator
24.1	Quantity		1 No
24.2	Make		*
24.3	Display		LCD 3 1/2 Maximum: "1999" However, in the 20,000 lx range, the max is "19,990" and in the 2000,000 lx range, the max is "199,900". Battery low

Sl. No.	Item	Unit	Requirement
			display indicator , EL backlight function
24.4	Display operation		20,200, and 2000 lx ranges: 1-count steps
			20,000 lx range : 10-count steps
			200,000 lx range : 100-count steps
24.5	Measuring Ranges		20/200/2000/20,000/200,000 lx Auto range / manual switching
24.6	Overflow indication		"OF" is displayed
24.7	Accuracy		± 4% rdg. ± 1 dgt. (23 ° C ± 5 ° C)
24.8	Angle incident light characteristics (deviation from cosine characteristics)		Angle of 10°: ± 1 % 60°: ± 7 %
			30°: ± 2 % 80°: ± 25 %
			50°: ± 6 %
24.9	Response characteristics		Response to ultraviolet and infrared radiation: less than 1%
24.1	Fatigue characteristics		Change in value one minute and ten minutes after light strikes sensor: ± 1 %
24.11	Response time		Auto range: 5 sec or less & Manual range: 2 sec or less
24.12	Temp. characteristics		Deviation from value measured at 23 ° C between -10 ° C and 40 ° C: ± 3 %
24.13	Humidity characteristics		Deviation from value measured in an environment with a temp. and humidity of 23 ° C & 45% to 75% RH when unit is left in an 85% to 95% RH environment for three hours and then is returned to original environment: ± 3 %
24.14	Characteristics regarding intermittent light		Deviation in value when subjected to intermittent light for 1/2 cycle at a frequency of 100 Hz or 120 Hz: ± 2 %
24.15	Relative spectral response characteristics in the visible spectrum		Deviation from spectral luminous efficiency: 8 % or less
24.16	Receptor element Operating Temperature & humidity range		Silicon photodiode - 10 ° C to 40° C, 80% RH or less, with no condensation
24.17	Analog output		DC 200m V f.s ± 2.5% f.s (versus the display value)

Sl. No.	Item	Unit	Requirement
24.18	Power supply		R6P (AA) x 2 (3V) or AC adapter (6V, 300 mA)
24.19	Continuous operating time		Approximately 25 hours
24.2	Accessories		Sensor cap, portable case, R6P manganese batteryx2, warranty card, Manual
25	**Thermal Image camera (Portable)**		
25.1	Quantity		1 No
25.2	Make		*
25.3	Type		Camera shall be suitable to monitor the thermal image of the equipment & analyses the results in PC/computer

CHAPTER 30: PLANT COMMUNICATION & PUBLIC ADDRESSING SYSTEM

30.1 Scope of Work

This specification covers the general design, materials, construction features, manufacture, shop inspection and testing at the manufacturer's works, delivery at site, handling at site, erection, testing, commissioning, performance testing and handing over of Plant communication & Addressing system.

The following list of items/systems are covered under Clause 4, 5 and 6 in this specification.

i) Public Addressing system

ii) Radio communication system

iii) Plant communication system.

30.2 Codes and Standards

The design, material, construction, manufacture, inspection, testing and performance of equipment shall comply with all currently applicable standards, codes of practice, regulations and safety codes in the locality where the equipment will be supplied & installed. Nothing in this specification shall be construed to relieve the Contractor of this responsibility.

The codes and standards mentioned in the various specifications and requirements specified in the enquiry document shall be latest as on the day of award of contract of the works unless otherwise specified. Contractor shall be responsible to inform to the Consultant/ Owner in case of any revisions/reaffirm/amendment in the relevant codes and standards after the date of award of contract within 30 days of the issue of such revision/re-affirm/amendment of the code/ standard. Consultant/ Owner may approve use of the earlier code/ standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed.

The VENDOR shall ensure that instruments and gauges to be used for testing and inspection shall have valid calibration and the accuracy can be traced to National and International Standards as applicable.

30.3 Public Address System

The PAS shall be a two-channel (Party & Page) system incorporating the following operational features. The system shall be capable of being easily extended to accommodate functional units, loudspeakers, etc. in future. For this purpose, 10% spare capacity shall be provided in equipment, which shall be common for the complete installation. Various functions envisaged are-

i) To make public broadcasts of routine, situational, important and emergency announcements.

ii) To provide simultaneous broadcasting of different calls to different locations.

iii) To provide an automatic announcement facility for making routine, situational and emergency announcements, pursuant to externally interfaced alarms / indications.

Bidder shall provide PA system for the entire plant. The system shall cover the Control rooms, Switchgear rooms, Powerhouse building, Switchyard, DG house, Workshop, Transformer yard, GIS, Administration building, Security gates, Upper / Lower intake and as required etc. as indicated in the plot plan/layouts.

PA system shall have two modes, i.e. Paging mode and Party mode. Each of the two modes shall be open line, common talking type. Paging mode shall be used for locating a person and for general instructions. Party mode shall be used for conversation between individuals without broadcasting the same over the loudspeaker. The Public Address System shall be suitable for zones and sub-zones which can be accessed independently for announcement or alarm broadcasts.

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The PA system shall be with automatic central exchange (Digital type), Distributed amplifiers, modular type and easily extendable type. The system shall be complete with Master Control Stations (MCS), Central control Exchange (CCE) and end user equipment like wall / desk mounting type handset stations, loudspeakers, etc. The system will be adequately protected from signal and power line noise and meet the surge withstand capability (SWC) requirements of ANSI C37.90.1/ IEEE standard 472-1989 or equivalent.

Microprocessor based Automatic Central Control Exchange (CCE) with necessary communication channels between the master control stations and various zones depending on the requests shall be provided in the Central control room.

MCS shall be provided with a gooseneck microphone and membrane keypad. PB to automatically broadcast emergency / fire alarm on all systems shall be provided on the MCS.

Adequate number of handset stations with associated loud speakers shall be provided in various zones. Handsets shall be provided with Call Key Boxes (CKBs) wherever required with which communication can be established with other zones without the necessity of going through the MCS.

Inter-zone communication exists between two functional zones of the plant. All the communication facilities like paging and party mode communication between these zones shall be possible as if they have now become a single zone. This facility is enabled by handset stations with call key boxes and automatic central control exchange. However, the master control stations has overriding feature which can take control and avoid unnecessary conversations/announcements between the zones.

The proposed system shall be capable of having 4 simultaneous party conversations within each zone and also 4 simultaneous inter-zone party conversations. To achieve this, each handset station shall be provided with two channel selector switches, one for intra-zone channel selection and the other for inter-zone channel selection. The handset stations, which are not having call key boxes shall have channel selector switches for intra-zone channel selection.

The PA System shall have provision for interface with third party systems such as Fire Alarm system, Walkie-Talkie, EPABX etc. All the interfacing cables required between PA system & Fire alarm system, Walkie talkie, EPABX systems shall be in the Bidder's scope of work.

The PA system shall distribute alarm tones, pre-recorded messages, emergency voice messages and routine voice messages to all or selected areas of the facility, in a reliable and safe manner, by the use of loudspeakers. It shall be possible to configure/provide alarm tones.

Alarms shall be initiated either manually from any one of the dedicated access panels or automatically from the Fire Detection System via dedicated hardwired interfaces between the two systems. Voice messages shall be generated either from the microphones at dedicated access panels or from telephones in the facility or from system memory. A minimum of 15 pre-recorded messages can be provided in the exchange (Message/Tones).

In addition to the facilities to be provided by the Bidder as mentioned in relevant clauses of this section the Bidder shall make necessary arrangements for any other requirements that are essential to put the system in service.

Paging announcements shall be broadcast through loudspeakers installed in the various areas and locations throughout the facility. The system shall be modular in design and shall be easily expandable. The area of coverage shall be such that calls shall be clearly audible in the paged operating areas and their surrounding space.

Access panels / Master Control Stations shall support operator voice announcement and alarm control operations. Announcements are classified as "routine" or "emergency", where an emergency announcement shall take precedence over all other audio broadcasts. Announcements shall be pre-configured to broadcast in designated zones. A zone selection feature shall enable users to direct routine announcements to selected zones. Alarm operations shall initiate the broadcast of alarm tones or pre-recorded messages to pre-configured designated zones. Access panels shall be connected to the central equipment and accorded an

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access priority for announcements. Alarms shall be accorded a broadcast priority that gives the most critical alarm precedence. Each access panel shall be able to:

Address a call to one or multiple zones.

Address a call to one or multiple groups of zones, by activating the selected groups of zones.

Transmit a general call to the whole area activating all zones simultaneously. The speech messages shall be announced by an automatically generated pre-announcement attention signal.

Provision for selecting any of the 15 messages shall be provided in the MCS.

All MCS shall have equal priority.(First come first serve basis)

The access panels shall have facility to interlock to prevent interference on the call in progress for the same zone or group of zones. In addition, all audio signals to be broadcasted shall be able to be configured with different levels of priority in order to allow each signal to override the others where appropriate and where specified in accordance with specific site requirements.

The central equipment shall support external interfaces for telephone or other audio source interconnection for routine broadcast to designated zones. Each external interface shall be accorded an access priority for announcements. Additional interfaces shall support connectivity to external alarm

It shall be possible to initiate a general or emergency paging broadcast via authorised telephones.

The system shall provide facilities for the control and management of a high integrity public address and alarm system specially designed for industrial environments where advanced technology coupled with very high system availability is required.

The materials used shall have characteristics suitable for the installation site and for the service required. The equipment shall be fully solid state type, multi-microprocessor based and programmable. All the cards & modules shall be plug in type.

The system shall be software program controlled to enable easy system configuration and self-diagnostics, as well as future software upgrade. A user-friendly set-up and checking routine shall provide system management and programming, which enables an operator to implement quick commissioning and faultfinding functions of central exchange. The use of these methods shall allow adjustments to be easily made after the system is installed without resulting in modifications to the system wiring.

General System features

i) Public Address Announcements

ii) Configuration of Alarm Tones and Priorities

iii) Configuration of Announcement Priorities

iv) Pre-Announcement Tones

v) Zone Selection of Announcement and Alarms

vi) Pre-recorded Digital Tones and Important Messages

vii) Audio Recording

viii) Alarm Attenuation

ix) Party/Page Facility

x) Multiple Sources of Speech

xi) Supervision

xii) Emergency Notification

xiii) Paging Priorities

xiv) Plant Telephone Access

30.4 The PA system shall have the following main components & materials:

30.4.1 Central Controller Equipment

The control unit shall provide the heart of the PA system controlling audio routing from access panels, alarm generation, contacts inputs and outputs, amplifier control, and visual-audible indication of system status. The unit shall be microprocessor controlled with a hardware fallback circuit, which shall be capable of alarm generation and announcement in the event of processor failure. The software shall be designed to be as flexible as possible by making extensive use of configurable options to meet purchaser needs. The system shall be configured via an RS 232 / RS 485 / Ethernet port with appropriate software.

30.4.2 Interfaces

The central cabinet shall provide customised interfaces in accordance to Purchaser requirements. These interfaces support, but shall not be limited to, the following applications:

Telephone Announcement	: Supports telephone dial-in announcement facility; shall incorporate feedback elimination.
Facility Control System	: Supports alarm inputs and status reporting for an external system.
Fire Emergency	: Supports alarm inputs and status reporting for an external system.
Walkie-Talkie	: Supports announcement facility

Interfaces that support announcement facilities shall employ access panel and central equipment cards to inject and control audio for subsequent broadcast to pre-configured areas. These interfaces shall be at a lower priority than access panel or system alarm announcements.

Connection to external systems shall be through contact inputs and outputs. The inputs shall be implemented through a normally open relay contact wherein the external system energizes the relay for the normal state. A de-energized or open circuit condition on the line triggers the alarm response. Relay shall support outputs wherein either state can be supplied to the external system.

30.4.3 Access station sets and units

The access station sets and units shall be microprocessor based and connected to the central control cabinets. Access panels shall be custom designed to support system specific announcement and alarm operations in accordance with purchaser requirements. It shall be possible to make a manual or pre-recorded call to any pre-assigned zones or executing a predefined action. In terms of configuration, the design shall incorporate standard components, subsystems, units, kits and packaging formats.

30.4.4 Handsets

Each handset station shall have a handset, a spring return "Press to page" pushbutton, a spring return " loudspeaker mute" push-button, the necessary electronics and all accessories.

The PA System shall be of Distributed Amplifier type, i.e. each loudspeaker shall have a separate power amplifier of its own which may be located in the associated handset station enclosure or in a separate enclosure.

The Bidder shall consider following types of handset stations:

i) Type-A (Desktop Stations with extension amplifiers): The desktop stations are designed for mounting on control desks in Control room areas.

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ii) Type-B (Indoor type, wall/pole mounting stations): These stations shall be provided with a handset having the microphone and speaker. These shall consist of a back housing and a plug-in electronic module.

iii) Type-C (Weather proof wall/pole mounting handset stations) : The outdoor wall / column mounting type handset stations shall be dust-tight and weather -proof with appropriate protection against direct rain, ingress of dust and moisture conforming to IP 65 degree of protection as per IS 2147 with matching transformer, re-entrant horn with horizontal and vertical orientation facility and volume control. The handset station to be located outdoor shall have a canopy for protection against direct rain.

iv) Type-D: (Wall mounted pilfer proof stations): Handset stations located at isolated places shall be pilfer proof type. These stations shall be equipped with built-in microphone and speaker. Further all components on the front panel shall be so mounted that they cannot be removed unless special keys are used to open up the station first.

v) Type-E: Flameproof handset stations and flame proof loudspeakers with the details similar to type-C above respectively.

vi) Type-F: Portable station complete with handset, built-in speaker, amplifier, pushbuttons, indicating lamps and coupling cable terminated by a plug.

30.4.5 Loudspeakers

The loudspeakers shall be wall/pole, ceiling or desk mounting type for indoor applications. The loudspeakers shall be weatherproof, watertight and pilferage proof for outdoor applications, and/or explosion proof type (if required), depending upon the location in which they shall be installed. Mounting nuts and bolts shall be of stainless steel.

The unmatched speech frequency response and SPL characteristics shall ensure clear and intelligible sound even in noisy environment. The nominal power is intended as the power of a sinusoidal signal continuously applied without damage. All speakers of the same type shall have the same rated power and shall be adjusted to provide the required coverage.

30.4.5.1 Re-entrant horn type loudspeaker

All outdoor/indoor loudspeakers in areas of high ambient noise shall be industrial, re-entrant horn type. These speakers shall have pressure die cast aluminium construction horn, integrally mounted driver unit and mounting bracket for adjustment of speaker orientation in all directions. Back cover of the loudspeaker shall be fixed with pilfer proof screws. The mounting brackets shall be with adjustable base suitable for vertical and horizontal orientation.

30.4.5.2 Cone type/Box type Loudspeaker

Indoor loudspeakers mounted in control rooms shall be cone type and shall be housed in metal casing with grilled faceplate. The housing shall be treated with acoustic under coat to prevent resonance. They shall have IP-55 degree of protection as per IS:2147

All the cables required for the PA system shall be provided by the Bidder as required basis to complete the system and to maintain system integrity. The cables shall be stranded tinned copper conductor, PVC insulated, extruded PVC inner sheath, shielded, armoured, over all FRLS PVC sheathed, multi-core as per IS: 1554 /1 -88, IS-649, IS-5831/84, IS-10810, IS-3975 or equivalent standard. The cables shall be subjected to the entire test specified therein.

30.4.6 Auxiliary External Equipment

Wall/ column mounted junction boxes shall comprise of case and cover / door constructed from die cast aluminium alloy of thickness not less than 2 mm with cable gland having screw on cover, screwed terminals and cable entry only at the bottom and sealed. The junction box shall conform to enclosure class IP 67 for Outdoor area and IP-55 for Indoor area as per IS: 2147 and explosion proof as per area classification. The junction box shall be minimum 200 mm

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wide. However the height and width of junction shall be finalized during the detail engineering stage.

All junction boxes shall be provided with identical door locks and shall be operable with one main key. Terminal blocks shall be properly arranged inside the junction box for easy maintenance. 10% spare terminals shall be provided distributed over terminal blocks.

PA system shall support potential free alarm contacts to be integrated in SCADA.

Remote Operator station to be considered at Pooling Substation ends for making any announcements from remote stations.

The system shall be configured by Ethernet port and RS232/RS485 interface.

30.4.7 Radio Communication System

Wireless VHF/UHF based two way mobile communication system shall be provided for specific use during commissioning stage as well as for convenience during maintenance. The wireless system shall cover the entire power plant area, the range of coverage being 5kms in all directions from the main plant building and also communicate to 132/33kV Sub station and 400kV Pooling Station. The system shall include the following:

i) One set. UHF base station with antenna, repeaters, transmitter, power supply units, inverters, voltage stabilizers with all accessories at local and remote end.

ii) 15 nos. of handheld two way trans/receiver sets with Dual Tone Multi Frequency (DTMF) key pads and one nos mobile set to be installed on vehicle.

iii) Two charger units with provision for simultaneously charging six handsets.

iv) 5 No.s Single charging units also to be provided with handsets.

v) Satellite Phone for local and remote ends 4 No.s.

The wireless system shall be Multi-channel, analogue type, equipped for 8 channel expandable up to 16 channels in 330-400/403-470/450-527 MHz band.

Scope of work includes getting frequency allocation and licence from the Ministry of Communication, Govt. of India. Co-ordination with WPC wing for getting frequency allocation in 330-400/403-470/450-527 MHz band for 8 spot frequencies (However the Royalty & License fee payable to WPC wing shall be borne by Purchaser.). Co-ordination with WPC wing for getting full siting clearance for the antenna tower shall also be in Bidders scope.

As an alternative bidder is free to offer alternate radio communication solution in form of subscription-based trunking radio services offered by reputed and DOT authorized service provider. Purchaser will take care of annual subscription.

30.5 General

Radio communication system shall provide two – way wireless communication between static station and a number of portable/mobile stations and also between the portable/mobile stations.

Each system shall comprise of a base station and a number of portable/mobile (VHF/UHF) Trans – receiver sets.

The trans- receiver sets for each system shall be suitable for voice communication and the mode of operation shall be on simplex basis.

The trans- receiver shall be designed for having high carrier stability with adequate suppression of spurious emissions and a low distortion using fully transistorised circuitry.

The sets shall be of rugged construction and suitable for reliable operation under adverse environmental and operational conditions.

Each set shall comprise a synthesized, frequency modulated transmitter and receiver unit, built-in helical antenna with all controls, microphones and loud speaker and operated from self – contained 12V long life rechargeable nickel cadmium battery.

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The Radio System shall provide reliable in-building RF coverage for the entire plant as well as out-door coverage from the main plant to external areas.

RF coverage should be available from plant to 132/33kVSubstation and 400kV Pooling Station.

The radio users shall be able to initiate and receive telephone calls from the subscriber radio.

It shall be possible to add radios in to the system during channel expansion without requirements for recalling radios already being used on the system or reprogramming of radios already in use.

The sets and base station shall support point to point calls, conference calls, broadcast calls and emergency calls. Emergency calls should over-ride all other calls.

30.6 UHF Trans – Receivers

The trans – receiver set shall be fully transistorised and /or IC based, modular in nature, multichannel, frequency modulated, based on the latest development in the UHF field.

The sets shall be compact design, lightweight and low power consumption.

The set shall be of weatherproof type with min IP 54 and also complying to MIL STD C/D/F and TIA/EIA 603.

The walkie-talkie sets shall be of frequency-synthesised version in UHF band and shall be tuned to the respective spot frequencies.

Each channel of the Walkie-talkie set shall be able to be programmed to deliver RF power from 1W / 2W by the user.

User-friendly LCD screen shall be available with radios with keypads. This gives the user instant talk identification.

Each trans-receiver set shall comprise of transmitter section, receiver section, a control unit complete with all controls, microphone and loudspeaker, built- in helical antenna and rechargeable 12V nickel cadmium battery all housed in a splash proof cabinet cast from aluminium alloy.

All the radios shall be analogue type. All the radios shall be programmable for its frequency and other features through radio interfacing unit. All the hand held radios shall have keypad. All the radios shall have its own electronic serial number for its programming to protect unauthorized entry of new radios. Radio handheld sets shall be battery operated.

30.7 The handset unit shall conform the following technical particulars:

i) Frequency range : 330 to 400 M Hz /403 to 470/450 to 520 M Hz

ii) Number of preset : As required

iii) Channel provision

a) **Channel spacing : 25 kHz**

b) **Frequency stability : ±10 PPM**

c) **Maximum frequency: ±5kHz**

iv) Deviation

Type of operation : simplex, press to talk

Type of antenna : short helical antenna

RF power output : 2watt

v) Audio output : not less then 0.5 watt

vi) Battery voltage : 12 volts

vii) Controls : transmit button, speak/listen switch, call signal lamp.

30.8 The following minimum controls are required for Base station & portable/mobile radios:

i) On/Off switch

ii) 4 customised switch.

iii) Volume control.

iv) LED indication for transmission.

v) Full channel operating capacity & each channel shall be programmable.

vi) Alphanumeric Display.

vii) PTT switch

30.9 Telephones interconnect:

The telephone inter connect unit shall be programmable. This feature shall allow the radio unit to extend the communication to initiate and receive telephone calls.

30.10 Accessories:

The bidder shall supply all necessary connectors, cable with connectors for testing the repeater/fixed/portable radios. The testing cable shall be provided with BNC/UHF/N connector.

30.11 Circuit Diagram and Manuals:

The bidder shall supply 6 sets of as built relevant operation and maintenance manuals comprising of block diagram, interconnecting diagram, neat circuit diagrams, circuit description, test voltages, spare parts list, trouble shooting guide, tuning with procedures, list of testing equipment required along with supply. The bidder should also supply the programming kit and the required software.

30.12 Testing Equipments:

The bidder should recommend the necessary testing equipments for the maintenance trouble shooting of repeater stations, portable radios and fixed station radios and should quote for the same separately.

30.13 Antenna:

The supply of tower materials should be complete in all respects including all the accessories such as ladders, antenna fixtures, rest platforms, antenna platforms, lightning arrester, base plates, anchor bolts and templates, bolts-nuts, aviation lights, twilight switches and electrical fittings like conduits etc. Galvanised steel ladder should be provided from the ground level to the highest point of each tower. Guard loops should be provided to the ladder to protect the climber from falling. No structural members shall intrude into the guard loop.

The tower must be designed for self-weight and wind velocity of 180 km/Hr (also refer project information).

The wind pressure on the wind- ward should be taken as 100% of the designed pressure.

The wind pressure for the diagonal case should be taken as 1.18 times those in the normal case. The tower should be designed to support 4 -repeater station antennas and shall be mounted as per the requirement.

The top width of the tower shall be 1.8m.

Galvanisation: All steel members of the tower shall be hot dip galvanised in accordance with IS 4759-1968 (or as revised)

30.14 Lightning Arrester:

Lightning Arrester shall generally conform to IS – 2309-1969 (or as revised).



30.15 Material to be used for fabrication:

Tested steel as per specification given in IS-226-1975 (or as revised) shall be used for bolted work. All steel section used shall be rolled to the dimensions, sizes and weights specified for required subject to permissible tolerances as given in IS-226-1975 (or as revised). It shall be free from cracks, surface flaws, laminations, rough and imperfect edges and other visible defects etc.

30.16 Plant Communication System / Telephone System

The power plant shall be provided with sophisticated microprocessor-based intercom telephone system to facilitate intercommunication for operation / administrative purposes.

Electronic Private Automatic Branch Exchange (EPABX) consists of 250 lines capacity capable of expanding in future. 170 analog, 50 Digital, 30 IP phone instruments to be provided. The EPABX should have engine capacity of Minimum 500 lines. The offered system should be considered with suitable licenses for integration on SIP with any make VOIP systems and should support seamless feature transparency.

EPBAX shall be suitable for integrated service digital network (ISDN) and approved for connection to the public switched telephone network (PSTN). A personal computer (PC) based telecommunication console shall be provided together with a VDU, keyboard and hand set. The EPBAX system shall incorporate a self-surveillance facility for monitoring the status of EPBAX equipment and appropriate alarm shall be raised automatically to alert the operator when a fault is detected in the system.

Necessary integration and extension of phones to be carried out from Powerhouse to 132/33 kV Substation.

The electronic exchange shall have all the standard features viz. circuit for interconnecting any extension, tone generator for ringing, ring back, ready for dial, extension engaged night station features etc. Keypad type of instruments with auto dialling feature shall be provided for all subscribers which shall have push buttons with 0 to 9 digits. All the instruments for subscribers, will also have the provision for hooking up with P&T lines.

Analog telephone instruments having a small 2-line graphical monochrome display, Four-directional navigation keys with scrolling, 6 multi-function display keys and Speakerphone, instruments to be support alphanumeric clip display. Bidder to consider and provision hotline connectivity, 6 party casual conference feature along with minimum 20 party bridge. Digital telephone instruments having large/multiline graphical display (colour or B/W), Four-directional navigation keys with scrolling, at least 6 multi-function display keys, speaker phone with acoustic echo cancellation and support for boss-secretary call management features. Digital instruments should have provision to integrate multi key modules.

SIP and PRI interface card to be considered. Bidder to consider and provide PRI/SIP from service provider for digital inward and outward dialling. EPABX should be provided with structured cabling on patch panels with I/O in rack.

Special instruments to be considered for Control room with advanced functionalities for operating in the control room operation modes.

EPABX system shall have separate DC System and maintenance free lead acid batteries with a duty cycle of 10 hours (min).

The telephone sets are to be installed in various areas of power plant.

All telephone sets shall be of modern attractive design. Shell and handset shall be made of high impact-resistant, dust tight and temperature resistant plastic. The push button set design shall be supplied. All kinds of sets shall be equipped with snap-in modules for the push button units, tone signal source, handset and signalling buttons. The tone signal source shall be infinitely adjustable in volume.

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The handset shall be equipped with high quality transmitter and receiver insets. The push button mechanism shall be compatible with all dial systems according to ITD recommendations.

The telephone system shall be provided with all modern features such as, extension features, intrusion, call waiting, internal add-on conference, external add-on conference, abbreviated dialing, call division, intercept calls, call monitoring and billing etc.

In hazard areas such as oil storage, wall telephone sets with explosion proof and corrosion resistant metal cases shall be provided. Acoustic hoods shall be of FRP type in all high decibel level areas.

30.17 Other Specific Requirements

i) Satellite phone along with suitable docking stations to be considered as part of control requirement.

ii) It is recommended to plan a site visit by bidders before bidding, which will enable to finalize the scope and required BOM and to understand the installation and fitting scope appropriately to meet all the functional requirements specified. Wherever site is not ready bidder should refer project drawing / site civil drawings of plot plan, building floor plan, indoor / outdoor area plan to finalize the scope and required BOM.

iii) Bidder should offer warranty and AMC support with signature/license/firmware updates from OEM for 7 years.

iv) Security updates and patch upgrades to be considered by bidder for minimum period of 7 years at no additional cost for all communication equipment's offered.

v) Demonstration / testing of the system at OEM's works before dispatch of the system at site (FAT). This testing will include engineers for physically witnessing the FAT.

vi) Bidder shall arrange for training of Engineers at OEM's place for Minimum 10 engineers covering Basic to Advanced system training. Bidder also to include certification Training for Engineers.

vii) Bidder shall consider 10% spares which should be handed over to purchaser engineers after SAT.

30.18 Earthing

The arrangement of earthing for functional and protective, personnel safety purposes shall be provided to ensure correct operation of equipment or to permit reliable and proper functioning of installations.

30.19 Cabling

Armoured PVC cable shall be used when the cable is to be laid in concrete cable trench / cable tunnels / overhead cable galleries / directly clamped on the walls or structures.

Un-armoured communication cables shall generally be laid through PVC casing (above false ceiling) / concealed conduits embedded in walls and for surface conduits along wall / structure by GI pipes.

The signal cable shall be twisted pair, annealed tinned, stranded Copper conductor, PVC insulated, PVC sheathed with electrostatic screening and GI round wire armoured with overall FRLS PVC sheath.

30.20 Testing And Inspection

Certified copies of reports of type tests carried out on similar type and rating of various equipment (supplied under this contract) within last five years from the date of submission of Bid shall be furnished to the Purchaser for review and approval. In case the type test reports are not found to be meeting the specification requirements, the Vendor shall conduct all such tests under this contract free of cost to the Purchaser and submit the reports for approval.

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All acceptance and routine tests as prescribed in the relevant IS, IEC and ANSI/IEEE standards shall be carried out on all the equipment/components under the scope of this contract. These tests shall be performed on all units. Charges for these shall be deemed to be included in the equipment price.

A list of commissioning tests for the whole system shall be mutually agreed upon & the same shall be provided as a part of Quality Assurance plan by the Bidder.

The Bidder shall be fully responsible for the satisfactory erection, testing, commissioning, start-up and trial operation of the communication system's equipment and it's associated cable network.

30.21 Mandatory Spares

SL NO	**Equipment**	**Quantity and particulars**
1	**Public Address System**	
1.1.	Electronic cards	1 set of each type
1.2.	Power Supply	1 No. of each type
1.3.	Amplifiers	1 No. of each type
1.4.	Handsets	1 No. of each type
1.5.	Microphone & Loudspeakers	1 No. of each type
1.6.	Set of spares for Radio communication	1 Set of each type
1.7.	Walkie-Talkie	1 No. of each type
1.8.	Cable	10% of Total Qty
1.9.	Connectors	5 sets of each type

CHAPTER 31: SECURITY AND SURVEILLANCE SYSTEM

31.1 Scope

Scope of the work under this chapter covers supply of materials, labours, tools, plants and performance of work necessary for the design, manufacture, quality assurance, qualify control, shop assembly, shop testing, delivery at site, site storage and preservation, installation, commissioning, performance testing, acceptance testing, training of Employer's personnel, handing over to KHPL and guarantee for two years of security and surveillance system as per the specifications hereunder, complete with all auxiliaries, accessories, spare parts and warranting a trouble free safe operation of the installations.

The scope of work shall be a comprehensive functional system covering all supply and services including but not be limited to following:

31.1.1 Security and Surveillance system

i) IP based CCTV surveillance system comprising of cameras, keyboards, high resolution colour monitors, Network Video Recorder (NVR), associated software, cables and other required hardware and accessories.

ii) LED based 50" full HD colour monitor (LSD) for powerhouse complex.

iii) Spare parts in accordance to clause 30.8 "Spare Parts" of this chapter.

iv) Tools and instruments in accordance to clause 30.9 "Tools and Instruments" of this chapter.

Any other item(s) not mentioned specifically but necessary for the satisfactory completion of scope of work defined above, as per accepted standard(s)/best international practices.

31.2 Specified Parameters and Layout Conditions

31.2.1 General

The major areas are as follow:

i) Each floor in Powerhouse block,

ii) Each floor in Control block,

iii) Elevator

iv) Transformer cum GIS cavern,

v) Connecting tunnel between powerhouse and transformer cum GIS cavern,

vi) Ventilation tunnel entrance,

vii) Cable tunnel & its entrance,

viii) Main access tunnel & its entrance,

ix) Adit to pressure shaft from MAT,

x) Outdoor Pothead yard area including DG building & switchgear building,

xi) Dam area

The security and surveillance system of all the zones/ areas will be seamlessly integrated for monitoring from control room at powerhouse or from security room at MAT/agreed during detail engineering.

All the cabling necessary for installing & commissioning of security & surveillance system shall be included in the scope. The cameras located at Dam and other areas will be integrated with SCADA system for monitoring from powerhouse control room.

Viewing of the video images on all the powerhouse computers shall be ensured with password protections through LAN.

The systems in the control room shall be designed to place all accessories required for the system completion.

Records/ archives of security and surveillance system shall be accessible through password from other computers connected to network. Clear vision of the above mentioned areas shall be ensured with high-resolution cameras as per the requirement.

31.2.2 Power Supply Arrangement

The available power supply for the security and surveillance system shall be 415 V AC. The required voltage level for the system shall be arranged by Bidder through suitable converters.

The security and surveillance system shall be fed through inverter system covered under "Chapter 24-Lighting System" in order to maintain the supply in case of power failure.

31.3 Rating and Functional Characteristics

Ratings and functional characteristics of all the components of the security and surveillance system shall be of latest state of the art at the time of supply.

If the system components mentioned in the awarded contract becomes obsolete at the time of supply, the bidder shall offer a latest model without any extra cost to KHPL.

The components of the system shall be selected taking the following requirements into consideration:

i) Reliability of components and subsystems,

ii) Scalability of the system for future extensions,

iii) Availability of spares,

iv) Ease of maintenance.

31.4 Performance Guarantee

The security and surveillance system along with all auxiliaries and accessories shall be capable of performing intended duties under specified conditions. The bidder shall guarantee the reliability and performance of the individual equipment as well as of the complete system.

31.5 Design and Construction

31.5.1 Standards

The system and equipment shall be designed, built, tested and installed to the latest revisions of the following applicable standard. In the event of other standards being applicable they will be compared for specific requirement and specifically approved during detailed engineering for the purpose:

Sl. No.	Standard	Description
	IEC 60065	Audio, video and similar electronic apparatus –Safety requirements.
	IEC 60326	Printed Boards
	IEC 60446	Basic and safety principles for man-machine interface, marking and identification, identification of conductors by colours or numerals.
	IEC 60478	Stabilized power supplies, DC output
	IEC 60870-5	Tele-control equipment and systems

31.6 Security System

31.6.1 IP Based Access Control System

Access control system shall ensure maintenance of attendance records of all employees, entry and exit of visitors along with means for tracking.

Each entry point / access door for entering into the zones shall be controlled though access control panels for authorised entry into the zones, depending upon functional areas such as Powerhouse & Dam control room, machine hall, electrical and mechanical areas, GIS, All the Entrance to Powerhouse & Dam etc., offices, rooms, facilities and utilities entry to which shall be controlled through access control panels for authorised entry depending upon level of authorization.

31.6.2 Access Control Panels

It shall have at least the following features:

i) Supports for all major card reader technologies and card formats,

ii) Distributed data base for independent operation,

iii) Operation in local or remote site configuration,

iv) Suitable no. of buffers and their future expandability,

v) Sufficient card memory and its future expandability,

vi) Suitable no. of time zones control card access, relays and alarm points,

vii) Time programmable relay,

viii) Back lighting on keypad,

ix) Non-volatile memory in case of power loss.

31.6.3 Proximity Card Readers

i) Positive reader indication to ensure a successful read,

ii) Indoor/Outdoor design to suit harsh environmental conditions,

iii) Suitable signal processing technique to communicate with proximity card,

iv) Sufficient card Read range,

v) Provision of card readers on both entry and exit doors to maintain the record of entry and exit time of the person.

31.6.4 Proximity Cards

1000 nos. of Proximity card shall be provided. It shall have at least the following features:

i) Smart contact less card based on RF,

ii) ISO Credit card size and thickness,

iii) Easy printing on both sides,

iv) Convenient and reliable access control without physical contact between reader and card,

v) Flexibility to be presented to the reader head at any convenient angle,

vi) Security with sufficient number of unique codes,

vii) Flexible and strong to resist cracking and breaking,

viii) Easy to carry in wallet or purse,

ix) Compatible with photo ID systems,

x) Read range shall not be affected by body shielding or variable environmental conditions, even when close to keys and coins, High durability.

31.6.5 Access Control Software

It shall have at least the following features:

i) Time attendance storage facility,

ii) Password protection,

iii) Easy to understand screens and menus,

iv) Control access to areas of powerhouse building, locating the whereabouts of a particular card holder and listing the users currently available in powerhouse,

v) Easily expandable to accommodate future growth of software,

vi) Facility to network multiple users at a location,

vii) User friendly to allow the system administrator to configure, monitor, control and report on all activities and resources in the system,

viii) Able to deliver the full customised reports of arrival, early arrival, late arrival, exit, early exit, over time, irregularities, etc. of employees on daily, monthly and yearly basis.

31.6.6 User Enrollment System

A user Enrolment System shall be provided for registration of new users and printing the visitor labels. The system shall be provided with PC workstations and software, Camera, badge printer and visitor badges / labels to print visitor labels.

31.7 IP Based Closed Circuit Television System (CCTV)

31.7.1 Generals

i) The CCTV System shall be meant for gathering video information from the various areas of the plant with display and recording facilities with night vision and motion sensors as per requirement per requirement.

ii) A complete integrated CCTV system with all hardware and software as required shall be supplied to enable on-line monitoring and to generate a record to facilitate post event analysis. All components of the system shall be designed for continuous operation. The area under surveillance shall be monitored and controlled from the Control Room through workstation and mouse/keyboards.

iii) The CCTV system shall be high quality, high performance, network based, and digital video security systems and shall be designed to allow persons to be clearly seen at any position within the area of coverage. The camera locations shall be such that full coverage of the station shall be provided.

iv) IP based Camera system shall be provided for CCTV monitoring. All cameras and CCTV system shall be connected to Industrial Ethernet switches through Fibre Optic cable for transferring camera video signals. Ethernet switches will then be connected to a network controller to a separate high-speed LAN that shall handle high-capacity video files.

v) The CCTV System along with all its system components i.e. network switches, storage devices, servers, LAN switches, media converters etc. shall be powered from UPS system.

vi) The number of cameras and their locations shall be such that all critical areas are under surveillance and can be viewed in control room or other monitored point. The minimum quantities of IP camera shall be One Hundred (100), however, this quantity to be reverified based on project Layout.

vii) The system shall be suitable for installation and shall be able to work successfully in hydro power plant environment and shall have facilities like zooming, pan control, tilt control, computer interface, logging printer port, multiple prepositions, group switching, programmability, alarm interface, interface with the LED screen in control room for displaying the pictures through suitable window.

viii) The system shall comply with the following operational requirement:

a) From the master control panel (keyboard), it shall be possible to select any camera and display the picture on any of the monitors.

- **b) Commands from the video switcher/control unit shall be sent via an onsite receiver/drive unit to the camera which in turn controls the pan/tilt zoom etc., functions.**

c) Operator shall be able to control all the cameras, pan / tilt and zoom functions manually.

d) **The Network video recorder shall record the activities of all the places where alarm have been alerted**

31.7.2 IP Cameras

IP Camera shall keep watch within its range for which it is fixed. The camera assembly shall comprise of colour camera with high resolution, zoom lens, housing, pan/tilt unit, auto-iris, and on-site receiver/driver unit. The camera shall be weather proof (IP67).

31.7.2.1 General

The IP Camera shall have at least the following features:

i) 360 degree continuous pan rotation,

ii) Variable scan speed (1-40 degree/sec),

iii) ¼-inch format CCD imager,

iv) Zoom: min. 27x optical &min. 12x digital,

v) Resolution: at least 540TV Line,

vi) Minimum illumination: 0.1 Lux (Colour) &o.00015 Lux (B/W),

vii) Signal –to-noise ration:>50dB,

viii) Input voltage: 240 VAC,

ix) Indoor/outdoor applications,

x) Adjustment for minimal lighting,

xi) Suitable for night surveillance.

31.7.2.2 Pan and tilt Units

The pan and tilt unit shall comply with the following:

i) Pan range: 0º to 360º movement in horizontal plane,

ii) Pan speed: 0.0 to 150º /sec,

iii) Tilt: +2 degree to -92 degree movement in vertical plane,

iv) Tilt speed :0.1 to 40 degree/sec

31.7.3 Portable Cameras

Portable Camera shall keep watch within its range for which it is fixed. The camera assembly shall comprise of colour camera with high resolution, zoom lens, housing, pan /tilt/zoom unit, auto-iris, on-site receiver / driver unit.

Four (4) Nos. portable cameras shall be provided with all accessories for connection to any desired location of the powerhouse.

31.7.3.1 The Portable Camera shall have at least the following features:

i) 360-degree continuous pan rotation,

ii) Variable scan speed (1-40 degree/sec),

iii) 1/4-inch format CCD imager,

iv) Zoom: min. 27x optical & min. 12x digital

v) Resolution: at least 2 Megapixel,

vi) Minimum illumination: 0.5 Lux (Colour) & 0.05 Lux (B/W),

vii) Signal-to-noise ratio: >50dB,

viii) Input voltage: 240V AC,

ix) Indoor/outdoor applications,

x) Adjustment for minimal lighting,

xi) Suitable for night surveillance.

31.7.3.2 Pan, Tilt And Zoom (PTZ)

The pan, tilt and zoom shall comply with the following:

i) Pan range: 0° to 360° movement in horizontal plane,

ii) Pan speed: 0.1 to 150 °/sec,

iii) Tilt: +2 deg to –92 deg movement in vertical plane,

iv) Tilt speed: 0.1 to 40 deg. /sec.

31.7.4 Camera Housing

All the cameras and accessories shall be housed in weatherproof environmental housing made of aluminium or other superior material. The housing with heater and blower installed shall provide protection for camera/lens assemblies in the ambient temperature range of 0ºC to 40ºC. The housing shall also have thermostatically controlled heater kit, continuous duty blower kit, available within the housing.

31.7.5 Network Video Recorder (NVR)

An enterprise class recording system shall be provided that can store and play back images from any number of cameras at 30 images per second per camera simultaneously. These images shall be transferred to a number of redundant arrays of independent disks (RAID) storage units for safekeeping and shall be possible to be recalled from view stations connected to network. There shall be provision for adding more no. of view stations, recorders and video storage units.

The recording system shall consist of following main components:

A. View Station

View station shall be used to view live or playback video from any camera. It shall have following main features:

i) Seven different access levels for configuring operator functions,

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ii) View at least four cameras simultaneously,

iii) View live or recorded video simultaneously,

iv) Include mouse and key board,

v) SVGA monitor outputs or composite outputs,

vi) Preloaded with latest professional version of Microsoft Office along with any other software required.

vii) TCP/IP addressable

B. Recorder

The recorder shall act as the server for the system. All of the cameras shall terminated at the recorder and the video signal shall be digitised, compressed and sent to the storage unit. The server shall be connected to the network and send all live and playback video to the view station upon command. The recorder shall have following main features:

i) Capability for recording at least 30 images per second per camera with recording resolution of at least 720 x 288 pixels,

ii) Continuous, scheduled, motion detection and alarm recording,

iii) TCP/IP addressable

C. Video Storage Unit

Video storage unit shall be capable of storing at least three (3) months video directly on systems hard drives for instant retrievable and playback. It shall have following main features:

i) Hot-swappable drives in case of failure,

ii) SCRI interface for faster video transfer,

iii) RAID 5 configuration,

iv) Back-up power supply and fan module

31.7.6 High Resolution color monitors

Four (4) no. of colour monitors shall be provided in security and surveillance room provided at powerhouse control room or some specific location of powerhouse complex to ensure simultaneous viewing of powerhouse locations in sequence.

It shall be 21" flicker free LD backlit full HD flat screen colour monitor with features like built-in speakers, automatic colour switching system, front panel controls, video and audio input and output, automatic degaussing, fast warming time, ract mounting kits, controls etc.

Control features should include colour system select, volume, colour, brightness, contrast, power, video input select, etc.

31.7.7 High Definition Color Monitor for CCTV

LED based full HD monitor, located in Control Room (Powerhouse), will be used as a main monitor and view live ficture from the CCTV cameras located at various sites. The major features of the monitor are as follows:

Screen Size	: 85 inch
Aspect ratio	: 16:9
Viewing angle	: More than 160 degree
Video System	: PAL
Stand	: Roof hanging type/wall mount type

31.7.8 Keyboards

Keyboards shall have full function used for system control and programming. It shall be ergonomically designed. It shall be connected to the video switcher/control system for signal and power.

31.7.9 Junction Boxes

The Junction box shall be constructed with suitable locking arrangement.

All junction boxes shall have minimum 20% spare terminals for future requirements.

All junction boxes hall have minimum of IP-67 protection. Disconnecting (sliding) cage clamp type terminal blocks shall be provided, to facilitate testing and maintenance without disconnecting the cables.

31.7.10 Cables

Cables for use in security and surveillance system shall be of FRLSH PVC sheathed cables and shall conform to latest edition of Indian/International standards. Video cables shall maintain high quality of signal for at least ten (10) years.

Cables shall be suitable for installation as follows:

i) Above ground in open air location (tray/ducts) in tropical, humid and corrosive atmosphere prevalent to power plant,

ii) Direct hurried in underground trenches conduits with uncontrolled back fill and possibility of flooding by water and chemicals,

iii) Laid underground in RCC lined cable trenches with possibility of flooding by water.

Cabling shall be done at various important locations of the powerhouse to ensure the portable camera connection wherever needed.

31.8 Drawings, Documents and Design Calculations

31.8.1 Design Memorandum

The bidder shall submit to Employer a design memorandum prepared in accordance to requirements stipulated in clause 2.5 of "Section 1-General Technical Specifications (GTS)".

31.8.2 Drawings and Documentation

The Bidder shall submit all the drawings and documents in accordance with requirement stipulated in clauses 2.6.1 and 2.6.1 of "Section 1-General Technical Specifications (GTS)".

31.8.3 Design Calculation

The Bidder shall submit the design calculation accordance to clauses 2.6.4 and 2.9 of "Section 1-General Technical Specifications (GTS)" covering at least the following, for review/acceptance.

i) No. of all the components for security and surveillance system with complete schematic diagram,

ii) Other design calculations as required.

The Bidder shall also provide other calculations as required by the Employer for his approval of the Bidder's design.

31.9 Delivery, Installation and Commissioning

The Bidder shall follow the requirements of Delivery, Installation and commissioning elaborated in clause 2.10 under "Section 1- General Technical Specifications (GTS)" under clause "Installation and Commissioning".

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31.9.1 Specific packaging, handling and storage requirements

The packaging and storage of electronic and electrical equipment shall be strictly in accordance with internationally accepted standards.

Electronic equipment shall be packaged, shipped and stored in anti-static packing. All packages shall be stored indoor. Packages containing electronic equipment shall be stored in humidity controlled environment.

31.10 Spare Parts

Mandatory spares shall be supplied in accordance to clause 2.8.12 of "Section 1-General Technical Specifications (GTS)".

Specific spare parts to be supplied under this section are as follows:

Sl. No	Description	Quantity
1	Electronic cards of each type used in the system	1 no.
2	Camera with zoom lenses and accessories	2 nos.
3	Cables of all type	100 m
4	Proximity Card Reader	1

31.11 Tools and Instruments

The Bidder shall supply all necessary tools and instruments etc. for installation, repair and maintenance in accordance to clause 3.2 of "Section 1-Section 1-General Technical Specifications (GTS)".

31.11.1 Special tools

The Bidder shall propose the list of special tools including their make and detailed specification as recommended by manufacturer(s), to be accepted by the Employer.

31.12 Quality Assurance and Testing

The Bidder shall follow the quality assurance and testing requirements specified separately in clause 12.2 "Section 1-Quality assurance and Testing and Inspection".

CHAPTER 32: FIBRE OPTIC COMMUNICATION SYSTEM

32.1 Scope of Work

This specification covers the design, engineering, constructional features, manufacture, inspection and testing at the VENDOR'S or his SUB-VENDOR'S Works, delivery at site including transit insurance, installation, testing, performance testing, commissioning & integration a complete and fully operational all hardware and software, accessories, and essential spares of fibre optic communication systems. Fiber optic terminal equipment (FOTE) shall be a hybrid equipment having both SDH STM-4 (STM – 4 upgradable to STM16) as well MPLS-TP with uplink speed of 4*10Gbps with an option to upgrade upto 40/100Gbps.

Scope of supply for fibre optic communication systems and accessories like Junction Boxes, approach cable, FODP and its' termination on FODP, connection between FODP to FOTE panel shall be as indicated in Data Sheet A1 / refer BOQ (Annexure-1). Scope of work shall also include the integration of FOTE with the SCADA Systems / substation automation (SAS) and other associated equipment.

The transmission line length would be in the range of 70 km. The Bidder should offer a suitable solution without involving Repeater Station. The proposed solution may be with Booster Amplifier wherever applicable.

Annexure-1 in the specification is an indicative BOQ. However, additional system requirement as stipulated in the specification shall be considered in the scope.

Voice and Data connectivity from Power House control room to Butterfly Valve House, Residential Colony, 132/33kV Control Room, Main Security Room, and other location in Powerplant is to be provided by Bidder. All required Hardware, software, components, and converters along with cable supply and Laying, Termination and accessories is by Bidder.

Training of the PURCHASER's Engineers and Jointers:

The VENDOR shall arrange to train PURCHASER'S engineer in jointing and terminating the Fibre Optic Cable at the time of inspection of Fibre Optic Cable by PURCHASER's personnel.

All the tests shall be performed and demonstrated as per standard requirement.

Lifetime (min 15 years) support for compatible spares and support services for offered systems.

All supply items and components in these systems should be latest at the time of commissioning and should not be at the end of the product life.

All supply items should be supported with Seven years extended warranty beyond contract warranty.

32.2 Codes and Standards

The design, material, construction, manufacture, inspection, testing and performance of fibre optic communication systems shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment/system will be installed. Nothing in this specification shall be construed to relieve the VENDOR of this responsibility.

The codes and standards mentioned in the various specifications and requirements specified in the enquiry document shall be latest as on the day of award of contract of the works unless otherwise specified. Contractor shall be responsible to inform to the Consultant/Owner in case of any revisions/reaffirm/amendment in the relevant codes and standards after the date of award of contract within 30 days of the issue of such revision/reaffirm/amendment of the code/ standard. Consultant/ Owner may approve

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use of the earlier code/ standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed.

The VENDOR shall ensure that instruments and gauges to be used for testing and inspection shall have valid calibration and the accuracy can be traced to National and International Standards as applicable.

In case of conflict between the applicable standards and this specification, the more stringent of the two shall govern.

32.3 General Requirements

The offered Equipment/System should have been working satisfactorily for more than 5 years in Telecommunication Networks operated by Power Utilities, as on the Bid Opening Date. Bidder should confirm continuation of regular supply of same Model of Fibre Optic Terminal Equipment (for any additional requirement) upto 10 years from the Date Issue of Order and availability of its Spare Parts for at least 10 years from date of Discontinuation of Regular Manufacture. Further, the published MTBF Values should also be furnished with the Bid. Offered PDH, SDH & Digital Tele protection Equipment should be of same make.

The Digital Multiplex Equipment shall be designed to operate in Electrical High Voltage Networks and shall be suitable for installations in Sub Stations with harsh environment and high Electromagnetic Interference. It shall be highly reliable and provide secure communications for Real Time Signals such as Voice, SCADA, Tele Protection, and Data including IP / Ethernet and Status / Control Signals. It shall comply with the latest ITU - T Recommendations and ETSI Standards and be able to be interconnected with legacy multiplex and other Telecommunication Equipment.

On transport level interfaces for optical transmission on 4*STM4 and 4*10G MPLS-TP in MSP shall be available.

The Equipment shall be of modular design and all modules shall form an integrated part of a 19” Shelf.

The Platform shall have means to cross - connect, drop and insert individual channels (64 kbps Time Slots), 2 Mbps framed (G.704) and Unframed (G.703) Signals. It shall also support termination and cross connection of VC 12, VC - 3 and VC - 4.

Equipment Protection and various Protection Schemes shall be supported.

For stations with Tele Protection and Telecommunication requirements, integrated/standalone Tele Protection Functions (Distance and Differential Protection) have to be provided.

Each network element shall be manageable locally and from an Operation Centre. There shall be means available to supervise external / existing Equipment via Binary Signals. It must be possible to access the platform over a TCP - IP Network. Access over SDH OHC channel using the OSI Protocol shall be possible

32.4 Fibre Optic Terminal Equipment (FOTE)

FOTE shall mean communication terminal equipment using digital transmission to transmit and receive voice, data (analogue & digital) and tele protection communication signals through fibre optic cable. FOTE shall form point to point, point to multipoint and multipoint to multipoint communication link. FOTE shall have capacity and expandability as indicated in Data Sheet A1. System shall be software based so that it is possible to configure, parameterize and monitor the system by software both locally and remotely.

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FOTE shall consist of Plesiochronous Digital Hierarchy (PDH), Synchronous Digital Hierarchy (SDH), user interface modules for applications as indicated in Data Sheet A1. FOTE shall also consist of MPLS-TP.

Optical transmitters and receivers (SFP) shall be modular in construction and separately packaged for easy replacement. The optical power output of transmitting devices shall be adjustable by changing optical trans receiver and shall be stabilized for variations of output due to changes in ambient temperature. Fully automatic gain control shall be provided for the optical receiver to cover wide range of input levels, due to various cable lengths, and to provide temperature compensation of the detecting device. Failure of transmitter or receiver at one end shall automatically turn off the corresponding receiver or transmitter at other end of the link. If hot standby is provided as indicated in Data Sheet A1, the standby equipment shall be switched on automatically to establish bump less communication. Local indicating and alarm contacts shall be provided at both ends of the link, to annunciate failure of the optical terminal equipment. The output of the transmitting device shall be adjustable by software programming.

The optical system shall be capable of overcoming the system optical attenuation at required transmission wavelength and providing reliable communication of good quality (cross talk attenuation between individual VF channels shall be not less than 70 dB in voice band).

The equipment shall be housed in 19" rack and shall have protection from dust, saline, corrosive and highly humid atmospheric and weather conditions. It shall be operated directly from either 220V DC or 230V AC (UPS). If any other power supply is required same to be derived from either 220V DC or 230V AC with the help of suitable redundant power supply module. System hardware design shall be energy efficient. Provision shall be made for accepting 2 nos. 220V DC/230V AC supplies in each cabinet. The efficiency of power supply unit shall be at least 90% with provision of over voltage and short circuit protection. Specific grounding and shielding features and requirements shall be indicated by the Bidder.

It shall be possible to insert or remove modules online (hot swappable).

It shall be suitable to integrate the time stamping signals from IRIG-B, PTP (IEEE 1588v2) and SyncE. And FOTE equipment synchronisation through 1PPS, 10 MHz, 2 MHz & SyncE input clock sources from external GPS or internal clock of FOTE. Bidder to consider PTP GPS for MPLS-TP synchronization.

Power supply modules shall be provided in redundant mode. The Bidder shall indicate availability of other redundancies mentioned below and switching facilities for the same.

Redundant modules at all hierarchical levels of Multiplexers and terminal equipment

i) Redundant optical module

ii) Redundant central controller unit

iii) Redundant user interface module

iv) Redundant time slots (channels)

Bidder shall provide power budget calculations so that equipment will operate in acceptable Bit Error Rate (BER) of 10-9 or better. System shall execute BER test automatically and inform the actual values and generate alarm. It should be possible to initiate BER test for various links both manually or automatically.

Functionality / Interfaces for direct connection to following USER SIGNALS shall be available on plug-in modules for the equipment:

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The Modules specified below are indicative, Bidder shall quote the actual module as per the system requirement to fulfil the functional requirements for the specified project.

i) Max four optical ports with transport capacity of STM - 4 SDH Optical Ports per Module for medium, long, extra-long and ultra-long distances, with 1+1/ path protection Automatic Laser Shutdown Programmable on each Interface. Out of these at least 2 Ports shall be upgradable to STM - 16 in future. Additionally, 2 spares STM-4 ports shall be provided for connecting in line in future, only SFP to be supplied in future.

ii) Tele Protection Commands per module: 4 Nos.

iii) Ethernet LAN Ports: 12 Nos. 10/100/1000 base T with Layer-2 functionality (with VLAN tagging- IEEE 802.1q & IEEE 802.1ad). Integrated Ethernet ports in optical & control card shall be acceptable.

iv) Eight numbers of 2/4 Wire E & M Interfaces per module with voice conferencing feature.

v) Four Ports Programmable Data Interface X.24 / V.11, V.24 / V.28,

   a) V.35, RS485 and Ethernet per module with data conferencing feature

   b) (Other than SLDC / Sub - LDC) and corresponding Ports at Remote End (nearest SLDC / Sub - LDC).

vi) 8 Port Layer 3 (OSPF – Open Shortest Path First) Router Board for Backup Data Communication at IEC 104 Ethernet.

vii) 2 Mbps Electrical Interface for Unframed Signals acc. To ITU - TG.703 and Framed Signals acc. to G.703 and G.704. E1 Interface Module with 8 ports minimum

viii) Analogue Subscriber Interface Modules with 8 ports minimum

ix) Analogue Exchange Interface Modules with 8 ports minimum

x) Alarm collection interface

xi) Optical interface module suitable for wavelength trans-receiver for up to

   a) 4 protection relays compliant to IEEE C37.94 for Differential Protection

xii) GOOSE Based Line distance protection Proxy Gateway interface

xiii) Binary signal (status and control) interface

xiv) 2 Mbit/s electrical interface for unframed signals acc. to ITU-T G.703 and framed signals acc. to G.703 and G.704

xv) n x 2 Mbit/s electrical SHDSL ports for TDM services supporting copper pair bonding

xvi) n x 2 Mbit/s electrical SHDSL ports for EFM services supporting copper pair bonding.

xvii) Any other Items

32.5 On Transport Level the equipment shall support the following connection ports:

i) Up to 8 x STM-16 SDH optical ports

ii) Up to 16 x STM-4 SDH optical ports

iii) Up to 8 x STM-1 SDH optical / electrical ports

iv) Up to 4 x 10GE Ethernet optical ports

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v) N x 2 Mbit/s electrical E1 ports

vi) N x 2 Mbit/s SHDSL ports

vii) N x 1 GbE optical / electrical ports

viii) Fiber Optic Terminal equipment should be integrated with existing available SDH and MPLS-TP multiplexers at 400kV Pooling Station. Integration services at remote end needs to be considered by bidder.

32.6 Multiplexing Terminal Equipment

The multiplexing equipment shall consist of a digital multiplexer, a digital demultiplexer, oscillator and line interface or optical terminal interface.

When channel capacity is specified in Data Sheet A1/BOQ, the multiplexing equipment shall be offered accordingly. If application requirement alone is specified, Vendor shall configure his multiplexing equipment in a manner to suit the application.

Failure of multiplexing equipment or high bit error shall be indicated on the equipment and corresponding transmission bit rate/bandwidth of the channels.

Further, the Bidder shall also indicate separately the number of channels each card can accommodate.

Bidder shall clearly indicate the maximum number of each type of interface cards which can be connected in a single.

Bidder shall indicate provision for automatic tail provisioning and re-routing of channels as well as bandwidth on demands.

It shall be possible to synchronize the electronic unit to internal clock or external clock signal such as PPS or PPM or clock from tributary or aggregate signal with automatic changeover based on set priorities without creating synchronization loop problems. System shall have manual and automatic reset facilities

32.7 OLTE Software & Network Management System

The network management system (NMS) shall have facilities to supervise, monitor, control and configure each equipment and the whole network. It shall have capabilities of fault, configuration, performance, and security management. It shall provide various graphical views to the network such as geographical overview, logical network structure, and hierarchical view. The network management system shall allow defining different user profiles.

A comprehensive alarm management shall show current alarms such that icons of the network elements change their colours according to the alarm level. The alarms shall be categorised as critical, major, minor alarms and warnings. A summary shall indicate the total number of alarms and warnings in the entire network. An alarm list shall list all alarms of the entire network according to the time of their occurrence. It shall be possible to filter alarms with various filter criteria. Operators shall be able to add comments to the alarms.

The DCN (Data Communication Network) to access all Network Elements shall be based on TCP-IP. The equipment shall use a dedicated router to forward DCN IP datagrams. In addition, the router will support OSPF as dynamic routing protocol.

System shall have automatic start-up diagnostics and cyclic background diagnostics during regular operation.

NMS software should support the third-party equipment management through an SNMP (Simple Network Management Protocol) for alarm monitoring and equipment configuration. Bidder to consider NMS with API licenses for integration with NOC.

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Configuration alarms, equipment faults, power supply alarms, loss of signal at receiving terminal, loss of incoming interface signal, loss of clock signal, high BER, loss of aggregate signalling, start-up and background alarms shall be initiated and reported. Alarms shall be time stamped and queued. It shall be possible to view/acknowledge/delete/log alarms. Alarm Indication Signal (AIS) shall be sent immediately after the detection of a fault condition. However, AIS shall be avoided during burst of high BER. Alarm shall be provided at the transmitting end to signal failure of transmission of data. The AIS shall be sent within fraction of a second after the beginning of the fault, including the detection time. For supervision at the receiving end, the following criteria shall be included for monitoring and signalling the alarm:

i) Optical receiving level too low

ii) Loss of synchronization

iii) Frame parity error

iv) Bit error rate greater than the set value

v) Failure of internal power supply

vi) Loss of signal at the receiving terminal

vii) Loss of incoming interface signal

viii) Optical transmitter degradation

ix) Loss of supervisory system

Alarms shall be signalled individually and shall also be transmitted back to remote stations to give a remote alarm.

Testing shall be facilitated by providing local and remote loop-back facilities and built-in test equipment (BITE). The System shall be capable of diagnostic function such as automatic/ manual self-test and local and remote software-controlled loops at aggregate level and in all interface cards at different levels and OLU without withdrawing from service. It shall be possible to make remote loop tests for the POT circuits as well. Both digital and metallic test access points shall be provided for input and output signals as well as facilities to force condition of the signals.

Both local and remote parameter setting in various interfaces and assignment of channels to various time slots shall be possible by software.

NMS shall be suitable to synchronize the external time stamping clock signal (SNTP).

System shall have latest proven version of software at the time of acceptance for achieving all the functionalities of the system as specified. All such software including system software, application software and user software as well as programming tools and documentation shall be supplied as part of the package.

32.8 Digital Protection Coupler (DPC)

The Digital protection signalling equipment is required to transfer the trip commands from one end of the line to the other end in the shortest possible time with adequate security and dependability. It shall also monitor the healthiness of the link from one end to the other and give alarms in case of any abnormality. The protection signalling equipment shall have a proven operating record in similar application over EHV systems and shall operate on 48V DC (+15%/-20%). It shall provide minimum four commands. These commands shall be suitable for direct tripping, Inter-tripping and blocking protection schemes of EHV lines.

The protection signalling equipment shall communicate to the remote end interfacing with SDH terminal equipment at its 2Mbps, V.11, G.603 64Kbps PCM, Optical or Electrical Ethernet port. It shall provide suitable interfaces for protective relays, which

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operate at 48,110 & 220V DC. Power supply points shall be immune to electromagnetic interface.

In order to guarantee correct operation of the distance protection relays the following performance parameters need to be met:

Guaranteed dependability and security as per IEC 60834-1 for distance protection signals, also in highly disturbed communication networks (e.g. with packet loss or bit errors)

Guaranteed back-to-back latency of < 5 ms for high and extra high voltage line tripping.

Availability of communication channel of 99.999%

Command addressing for tele protection signal shall be provided to prevent tripping if the signal is inadvertently re-routed through the telecommunication

An automatic and periodic loop test (< 100 ms) has to be provided for a signal delay measurement.

In case of loss of communication on main path a switch-over of the tele protection command to the standby path shall be < 5 ms

Trip counters shall allow the supervision of the tele protection functionality

Enhanced channel supervision and warnings and alarming in case of communication channel performance needs to be provided (approaching critical threshold/ critical threshold passed)

The configuration of the tele protection has to be integrated into the communication configuration tool of the multiplexer in order to ensure easy maintenance

The Tele protection function needs to be fully integrated into the network management system in order to ensure full visibility of the complete communication system

32.8.1 Principle Of Operation

During normal operation, protection signalling equipment shall transmit a guard signal/code. In case Protection signalling equipment is actuated by protective relays for transmission of commands, it shall interrupt the guard signal/code and shall transmit the command code to the remote end. The receiver shall recognize the command code and absence of the guard code and will generate the command to the protective relays.

All signal processing i.e. generation of tripping signal and the evaluation of the signals being received shall be performed completely digital using Digital Signal Processing techniques.

32.8.2 Loop Testing

An automatic loop testing routine shall check the tele-protection channel.

It shall also be possible to initiate a loop test manually at any station by pressing a button on the front of the equipment.

Internal test routine shall continuously monitor the availability of the protection signalling equipment.

Proper tripping signal shall always take the priority over the test procedure.

The high-speed digital protection signalling equipment shall be designed and provided with following features:

i) Shall work in conjunction with SDH terminal equipment.

ii) It shall communicate on G 703 (E1, 2 Mbps)

iii) Full Duplex operation

iv) Auto loop facility shall be provided

v) Shall meet IEC 60834-1 standard

vi) Shall be able to transmit upto 4 commands with trip counter simultaneously or sequentially in one 2Mbps channel

Bidder shall quote for protection signalling equipment suitable for 4 commands with separate trip counters for transmit and receive. Laptop for the above shall be supplied at each substation under substation package.

High security and dependability shall be ensured by the manufacturer. Probability of false tripping and failure to trip shall be minimum. Statistical curves/figures indicating above mentioned measures shall be submitted along with the bid.

The DPC can be either housed in offered Control & Protection Panel or FOTE Panel or Integrated type in FOTE rack.

32.9 IEC 61850 GOOSE Based Protection

A specific integrated interface for IEC 61850 based protection applications shall be available. The same shall be part of the IEC 61850 configuration of the substation and act as a gateway IED subscribing to the relevant messages for line distance protection. At least the following functionality shall be provided:

4 x FE/ GbE interfaces (SFP based) for direct connection with the station bus of IEC 61850 substations

Representation of remote IED for inter substation IEC 61850 GOOSE signal transmission

Filtering capabilities for GOOSE messages

Translation capabilities of GOOSE messages to resolve potential addressing/ naming conflicts between substations

Redbox functionality for connection to PRP redundant station bus (one card/ two card solution) as applicable for protection relays & SCADA System.

L2 firewall for access restriction from the WAN to the substation station bus

6 electrical IRIG-B outputs for synchronization of end devices to GPS Grandmaster clock

Optical IRIG-B output for synchronization of end devices to GPS Grandmaster clock

SNTP master functionality for providing time of day information to IEDs

SNTP client functionality for full IEC 61850 compliance

MMS status reporting to substation automation system for full IEC 61850 compliance

Enhanced traffic supervision features providing full visibility of the communication channel performance

Providing all optical interconnections from relay to relay through multiplexer without any converter boxes

Processing time of IEC 61850 GOOSE Gateway shall be less than 200 µs

32.10 Differential Protection

In order to guarantee correct operation of the differential protection relays the following performance parameters need to be met:

Guaranteed performance for the differential protection interfaces as per the standards (IEEE C37.94, ITU-T G.703, G.712, G.823, V.11)

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Guaranteed maximum end to end asymmetry of ≤ 400 us for all other legacy PDH interfaces commonly used for differential protection channels

Enhanced channel supervision as well as warnings and alarming in case of communication channel performance degradation (approaching critical threshold/ critical threshold passed)

In case of loss of communication on main path a switch-over of the differential protection channel to the standby path shall be < 50 ms

Guaranteed back-to-back latency of ≤ 6 ms for high and extra high voltage line tripping

Availability of communication channel of 99.999%

Differential protection should be supported over SDH as well as MPLS-TP.

32.11 General Conditions

The Equipment shall be capable of functioning as a Terminal, in 'Through Connection' (Transit, Repeater) Mode and as Add - Drop Multiplex. First Order Multiplexing (2 Mbps), Second Order Multiplexing (8 Mbps) and STM-4

Multiplexing shall be integrated. Conference for Voice Channels and Point to Multipoint Function for Data Signals shall be possible. The Equipment shall be of Modular Design.

32.12 Channel Switched Capacity: Digital Cross Connection

The cross-connection functions shall be implemented in such a way that no single point of failure exists. The PDH cross-connect capacity shall be up to 128 x 2 Mbit/s non-blocking with a granularity of 64 kbit/s.

Additionally, each SDH interface shall offer a high-order SDH cross-connect capacity of up to 128x128 VC-4 and a low order cross-connect for VC-3 and VC-12 in the same equipment with a capacity of up to 1008 x 1008 VC-12.

32.13 Packet Switched Capacity

The design of the backplane shall provide direct GbE connectivity between the different slots and the central(redundant) Ethernet switching matrix slots. Between uplink slot positions a backplane capacity of n x 10 GbE shall be available (n>2). For future upgrade purposes a 10 GbE backplane connection from the central Ethernet switching matrix to x different slots shall be available (x > 6). The central switching matrix shall at least support 60 Gbit/s full duplex switching capacity.

32.14 Redundant Centralized Functions Connection

The equipment shall provide enhanced redundancy features in order to ensure highest availability of the communication network. The following redundancy schemes shall be supported:

i) Redundant or distributed cross connect

ii) Redundant power feeding

iii) Redundant CPU functionality

iv) HW redundancy of SDH aggregate interfaces

v) HW redundancy of GbE and 10 GbE aggregate interfaces

vi) HW redundancy of voice and data conferencing

vii) HW redundancy of central Ethernet switching matrix

viii) Enhanced TDM traffic protection schemes

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ix) SNCP on 1 or 2 aggregate modules

x) MSP on 1 or 2 aggregate modules

xi) Enhanced PSN traffic protection schemes

xii) 1+1 and 1:1 LSP protection switching

xiii) Link aggregation on 1 or 2 aggregate modules

xiv) XSTP and ERPS loop prevention

32.15 Power Supply

The Multiplex Equipment shall operate from a nominal 48 Volt DC Battery with positive ground. The Equipment shall work satisfactorily over Battery Voltage Variations of ± 15 % (40.8 Volts through 55.2 Volts). Redundant Power Supply (N + 1 Protection) shall be supported. The Equipment shall support Dual Power Feed i.e. those two Power Sources can be connected directly to the Equipment (two Connection Points).

32.16 Safety

The Equipment shall be safe to use and shall comply with EN 60950 Class V1.

32.17 Electromagnetic Compatibility And Safety Regulations

The Equipment shall comply with the EN 50022 Class A, EN50082, IEC 801 - 2, IEC 801 - 6 and shall be conformant with CE.

32.18 Ambient Condition

Storage and transport:

i) Temperature Range : - 25°C to +70°C

ii) Humidity : max. 95% (no condensation)

Operation:

i) Temperature Range : - 20°C to +60°C

ii) In fan less configuration : - 20°C to +55°C

iii) Humidity : max. 95% (no condensation)

32.19 Mechanical Construction

The Equipment shall be available as a 19" Shelve to be mounted in a 19" Rack or 19" Cabinet. It shall be of robust design. All Modules shall be integrated in the same Shelf. All Connectors shall be accessible from the front and comply with International Specifications. The minimum cabinet depth required shall be stated.

32.20 Local User Terminal

It shall be possible to connect the Craft Terminal to any Network Element in the Network using the TCP - IP Protocol. The Craft Terminal shall support configuration, maintenance, and status information. It shall provide a 'Windows' oriented user Interface.

32.21 Path Protection

The Equipment shall provide means to protect 64 kbps Channels. The Protection shall be end to end from one Interface (Telephone or Data) to the other. It shall switch automatically from the Main Channel to the Standby Channel. It shall be configurable whether the System switches back to the Main Channel (Reversible Switching) or not (non - reversible).

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If a path has switched to its Standby Route because the Main Route is disturbed, this shall be indicated with an Alarm. The switching shall be done within the Multiplexer without using the Network Management System.

32.22 Section Protection

The Equipment shall provide means to protect STM-4 (MSP). It shall be possible to use two Independent Links: one as the Main and the other as the Standby. The System shall automatically switch to the Standby Connection and generate an Alarm if the Main Connection is disturbed.

The equipment shall provide means to protect STM-4 and 10G MPLS-TP (MSP).

The Switching shall be done within the Multiplexer without using the Network Management System.

32.23 Network Topology

It shall be possible to build point to point, linear, ring, T, and Meshed Networks.

32.24 Synchronization

It shall be possible to synchronise the Equipment using an External Clock Source, derived from a Network or with an Internal Oscillator. The Synchronization shall be configurable, and it shall be possible to distribute the synchronization to other Equipment as well. The System shall have the means of switching to select the Synchronization Source as well as a means of preventing the System from creating synchronization loops. The Equipment shall be capable of selecting the Source of Synchronization by means of SSM (Synchronization Status Messaging) on 2 Mbps PDH or SDH Port or by means of a Priority Based Sequence

For Tele Protection, Event – Recording, it shall be possible to synchronize the Clock of all Tele Protection Interfaces with one GPS in one station. The GPS Time shall be distributed over the Tele Protection Channel.

32.25 Alarms

Each Module shall supervise its functions and shall have an Alarm - Indication LED on its front. All Alarms shall be collected by the NMS. Each Node shall be capable of collecting up to 50 external Alarms.

32.26 Maintenance Facilities

Every Network Element shall have a built - in Signal Generator and Analyzer to analyse communication paths. It must be possible to connect the Generator and Analyzer to the Communication Channels and terminate the Signal on other Network Elements. It shall be possible to configure circuits locally with the Craft Terminal and remotely from the NMS or the Craft Terminal. It shall be possible to loop back signals locally and remotely using the Craft Terminal or the NMS.

32.27 Telephony

The equipment shall provide means to interconnect telephony subscribers and PBX systems. Analogue as well as digital solutions shall be supported.

i) Analogue two wire subscriber and four wire subscriber/ trunk solutions

ii) Digital VoIP subscriber and gateway functionality

iii) Power over Ethernet solutions

iv) Hotline services

v) Subscriber to PBX services

vi) PBX to PBX trunks

32.28 Requirements For Transport Level

32.28.1 SDH Modules

The Interface shall be designed for use on Single Mode Fibre (conforming to ITU - T G.652 or G.655). The Interface Card shall be based on SFP Technology and use LC / PC Connectors. The following Main Functions shall be supported:

i) Prepared for STM-1/4/16 SFP's (Small Factor Pluggable Units) for short, medium, long, extra & ultra-long Optical Communications (1310 nm and 1550 nm)

ii) Termination of the OS-, RS-, MS- and VC- 4 layer

iii) Extraction and Insertion of the SOH Communications Information

iv) Through Connections of VC - 12, VC - 3 and VC - 4

v) Support MSP (Multiplex Section Protection)

vi) Support of SNCP (Sub-Network Connection Protection)

vii) Ethernet over SDH (EoS) functionality based on GFP / VCAT / LCAS mappers

viii) 1+1 SETS timing protection

ix) 1+1 hardware protection

32.28.2 The following Maintenance Functions shall be supported:

i) Status Indications

ii) Loops

iii) Restart after ALS

iv) TTI Monitoring

v) BIP Error Insertion

vi) SFP inventory & diagnostics

32.28.3 The following SDH Interfaces shall be available

i) 4-port module 2x STM-4/16 and 2x STM-1/4

ii) 4-port module 2x STM-1/4 and 2x STM-4

32.28.4 PDH Modules

A 2Mbit/s E1 module for electrical communication shall be supported. Each module shall provide up to 8 x 2 Mbit/s electrical ports according to ITU-T G.703 and G.704. The ports shall be available for the synchronization source selection process. The interface shall be able to extract the 2.048 MHz clock for synchronization of the multiplex equipment. Support of SSM synchronization signalling shall be supported.

A high density E1 module providing at least 32 x E1 interface ports shall be available. Hardware protection of E1 circuit shall be possible. The same shall not require manual intervention such as cable change from main to protecting interface.

32.28.5 SHDSL Modules

The 2 Mbit/s SHDSL interface shall provide means to interconnect the multiplexer over one or two pairs of copper wire up to 10 km using G.SHDSL modulations. It shall communicate either with another interface of the same type or with a remote desktop terminal. Remote powering of the desktop terminal shall be available. Up to 8 x DSL interfaces shall be available on the module. The ports shall be available for the synchronization source selection process.

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In addition, a SHDSL interface complying with Ethernet first mile (EFM) standard as per ITU-T G.991.2 shall be available. The same shall provide at least 8 ports. The maximum capacity shall be up to 22.8 Mbit/s if pair bonding is used. The maximum capacity on 1 pair shall be up to 5.696 Mbit/s.

32.28.6 Ethernet Modules

Up to 4 x 10GE optical ports shall be available for Ethernet uplink purposes. The ports shall be available for the synchronization source selection process and support synchronous Ethernet (Sync-E / ESMC).

1GbE optical / electrical ports shall be available for Ethernet uplink purposes as well.

The uplink 1 GbE and 10 GbE uplink interfaces shall be upgradable to support MPLS framing in future

32.29 MPLS-TP Modules

MPLS-TP based aggregating port must be capable to support data rate of at least 10Gbit/s with an option for upgrade up to 40G/100G. It is preferred to have separate card for uplink connectivity & should not be part of control unit. Equipment should support minimum 4 uplink port in redundant configuration. Enhanced traffic engineering using MPLS-TP technology as per relevant IETF standards shall be supported by providing VPWS, VPLS and Tree services using the MPLS-TP infrastructure.

It is desirable that MPLS-TP & SDH technologies should be integrated in to a single platform. The packet transport equipment shall support scalability from 140Gbps up to 300 Gbps and shall support physical interfaces of 64Kbps and up to 1Gbps on the same platform.

On TDM TRANSPORT LEVEL, Circuit Emulation (CES) interfaces for SDH connections on STM-1 (155Mbit/s) and STM-4 (622Mbit/s) shall be available.

The equipment must be MEF CE 2.0 certified and comply with all service standards. Enhanced traffic engineering using MPLS-TP technology as per relevant IETF standards shall be supported by providing the E-Line, E-LAN, E-Tree and E-Access services using the MPLS-TP infrastructure

MPLS equipment should support various traffic protection schemes. MPLS equipment should support dynamic provisioning of LSP & pseudo wire transport paths.

MPLS-TP should support multiple protection on LSP tunnel / Pseudo wire as 1+1/1:1 for achieving recovery time less than 50ms. Supplied MPLS-TP equipment shall support ring, mesh & linear network topology.

Traffic engineering of the MPLS-TP network should be based on quality of service for each of the individual flows. Traffic flows will be identified at ingress side of the network as port based or VLAN based. Strict ingress and egress bandwidth control must be applied to guarantee bandwidth and performance for each individual service and avoid interference between pseudo wire traffic.

The following MPLS-TP functionality shall be supported:

i) Static/Dynamic configuration of MPLS-tunnels via configuration tool or network management system (NMS)

ii) Bidirectional MPLS tunnels.

iii) Priority handling using L2/L3 class of service information.

iv) Guaranteed performance parameters for teleprotection.

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v) Special care needs to be taken for mission critical services, extremely low latency, as well as jitter/ wander values shall be supported

vi) Port based MPLS assignment

vii) VLAN based MPLS assignment

viii) The following topologies shall be supported:

ix) Point to point virtual private wire services (VPWS)

x) Tree structures

xi) Virtual private LAN structures (VPLS) o Hierarchical VPLS structures

xii) End to end Operation Administration and Maintenance (OAM) channel with at least the following functionality:

xiii) Continuity check messages (CCM)

xiv) Loss of Continuity (LOC)

xv) Remote defect indication (RDI)

xvi) Frame delay (FD)

xvii) Route tracing (LSP ping)

xviii) 1:1 or 1: n traffic protection with < 50 ms switchover time

xix) Management functionality using dedicated MPLS channel

xx) Circuit emulation of legacy services via MPLS-TP shall be supported

xxi) Monitoring functionality to know traffic capacity.

MPLS-TP equipment should support interoperability with third party MPLS-TP/IP equipment's at the following interface levels.

i) E1

ii) C37.94

iii) Serial X.21, V.35

iv) Ethernet(1Gbps/10Gbps)

v) MPLS-TP transport level

vi) FXO, FXS

vii) HDSL/SHDSL

viii) IEC61850 Goose messages

Supplied equipment should support CDWM/DWDM wavelengths. It is desirable for MPLS-TP equipment to support auto provisioning of MPLS-TP node in case of any device failure.

MPLS-TP equipment in mesh or ring network of more than 50 nodes should be able to meet all performance requirement as per standards in terms of Latency, Asymmetry delay, Failover, Jitter. The guaranteed parameters should be demonstrated by the successful bidder during FAT & subsequently during handover process.

MPLS-TP equipment should possess diagnostic functionality & proactive monitoring features for troubleshooting of faults like loop test, ping, traceroute, BER, Optical diagnostics.



32.30 Scalability Of MPLS Solution

The following services should at least be supported:

i) At least protected 15 VPLS networks in parallel with 200 nodes in a hierarchical VPLS network, considering a backbone of 15 devices.

ii) At least 300 protected point to point links with guaranteed switchover time < 50 ms

iii) At least 500 protected point to point links with guaranteed switchover time > 100 ms

32.31 User Signal Interfaces

32.31.1 4 - Wire Interface (VF Interface)

This Module shall provide 8 connections for Voice Channels with a bandwidth of 300 Hz - 3.4 kHz and 2 Signalling Channels (M => E, M' => E') per Voice Channel. Each Voice Channel shall be configurable to operate with or without CAS. With CAS it shall use the "a" and "b" bits for the two signalling channels. The Level shall be software adjustable within the following Range:

i) Input: +7.5 to -16 dBr

ii) Output: +7.0 to -16 dBr

Modules where each Voice Channel can be individually configured with 1 + 1 path Protection shall be available.

32.31.2 Analogue Subscriber Interface (FXS)

A Module with at least 12 Subscribers as well as High Density Module for up to 30 Subscribers shall be available. The Ringing Generator shall be integrated on the Subscriber Module. The Ringing Frequency shall be adjustable for 20 Hz, 25 Hz, and 50 Hz.

The following Main Functions shall be supported:

i) **Downstream Signalling**

- Ringing, Metering, Polarity Reversal, Reduced Battery, No Battery

ii) **Upstream Signalling**

- On / Off - Hook, Pulse and DTMF Dialing, Flash Impulse, Earth Key General
- Constant Current Line Feeding, Line Test, Permanent Line Checks, CLIP (On - hook VF Transmission), Metering after on - hook

32.31.3 Exchange Interface (FXO)

This Module shall provide at least 12 ports for connection to the Ports for Remote Analogue Subscribers of a Telephone Exchange (PAX, PABX). It shall provide the following Functions:

i) Pulse Dialling, Tone Dialling (DTMF), Earth Key Function, Metering Function (12 kHz or 16 kHz), Flash Impulse, Polarity Reversal, Indication of Busy Lines

ii) The following Parameters shall be configurable by Software:

iii) Input Voice Level -5 +4 dBr, Output Voice Level -7.5 -1 dBr

iv) Metering Pulse Enable / Disable, Signalling Bit Definition,

v) Loop Back of Voice to the Telephone

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32.31.4 Voice over IP Subscriber Media Gateway

The module shall as a local concentration unit provide gateway functionality. PSTN (2-wire) subscribers over PSN shall be supported using the SIP protocol. Redundant connection to the VoIP PBX network shall be possible. Local call routing shall be supported in case of connection loss to the PSN network.

32.31.5 Party Line Telephone System (Engineering Order Wire)

An Engineering Order Wire (EOW) facility shall be provided at each Multiplexer. Following Options shall be available:

i) The EOW shall be configured as a Party Line and use in band DTMF Signalling to call another EOW -Terminal. The Terminal shall have an integrated DTMF Decoder allowing to program a Subscriber Call Number (4 Digits), and two group call numbers (4 Digits each) or

ii) EOW based on Voice over IP (VoIP). The EOW Traffic shall be routed over the Management Channel.

32.32 Data Interfaces

Following Interfaces shall be available:

i) V.24 / V.28, V.11 / X.24, V.35, RS485 Following Bit Rates shall be supported:

ii) Synchronous and Asynchronous: 0.6 … 38.4 kbps

iii) Synchronous: 48, 56, Nx 64 kbps (n = 1 … 31) Following Options shall be available:

iv) 1 + 1 Path Protection, Sub Rate Multiplexing, Point Multipoint, Performance Monitoring

32.32.1 64K Bits Co - Directional Interface

This Module shall comply with the ITU - T G.703 Part 1.2.1 for Co - Directional Data Transfer. A Module shall have at least 8 Interfaces. Modules where each Interface can be individually configured with 1 + 1 path Protection shall be available.

32.32.2 IP / ETHERNET Interface

The equipment shall be capable to provide at least 100 x 1GbE optical / electrical Ethernet ports.

Ethernet switching modules shall comply with the following specification:

i) Ethernet electrical connection: 10/100/1000BaseT

ii) Ethernet optical connection: 100Base-FX and 1000Base-LX/-SX/EX/-ZX

iii) Support of E-Line and E-LAN L2 services

iv) Support of VLAN tag stacking

v) Support of Ethernet over SDH functionality

vi) Support of at least 32 logical SDH WAN ports (EoS) per equipment

vii) WAN port capacity of at least 2.4 Gbit/s

viii) Framing according General Framing Procedure (GFP) ITU-T G.7041

ix) Virtual Concatenation (VCAT) acc. ITU-T G.707

x) Protection by means of Link Capacity Adjustment Scheme (LCAS) acc. ITU-T G.7042

xi) Protection by means of xSTP

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xii) A module with an integrated Ethernet Router shall be available with following function:

xiii) Ethernet connection: At least 10/100BaseT

xiv) Routing Protocols: Static IP routing, OSPF2 V2, RIP V2

xv) WAN protocols: PPP, MLPPP

xvi) WAN capacity: up to 16 x 2Mbit/s

xvii) WAN-ports: > 60

xviii) Redundancy VRRP (Virtual Router Redundancy Protocol)

A high-capacity layer 3 routing interface card with access to 1Gbit/s and upgradable to 10Gbit/s backplane shall be available with the following features:

i) At least 12 x FE/ GbE optical/ electrical SFP based front interfaces

ii) At least 4 x virtual routing functions (VRF/ VPRN)

iii) Wire speed forwarding on all ports (1GbE or 10GbE backplane access)

iv) At least IPv4 unicast routing (IPv6 ready)

v) OSPFv2 (RFC 2328)/ static routing

vi) OSPF authentication (Simple/ MD5)

vii) VRRPv3 (RFC 5798)

viii) At least 1:1 NAT, one instance per VRF

ix) At least basic firewalling (ACL rules/ DoS protection/ port and VLAN based rate limiting)

x) Layer 3 hardware supported QoS (DSCP/ 8 queues per physical

xi) port)

xii) 1:1 hardware protection (intra-chassis EQP)

xiii) SNMP MIBs (at least IF counters/ alarms)

xiv) Maintenance features (Ping/ trace route)

xv) At least 128 x VLAN interfaces per module

xvi) At least 128 x VRRP instances per module

xvii) At least 32 x VRRP link tracking per module

A module with Power over Ethernet shall be available to power e.g. camera, telephone set (Voice over IP). MDI / MDIX shall be supported on electrical interfaces.

Different interfaces providing Ethernet broadband switching functionality (L1 or L2) shall not work as independent switches. They shall contain one MAC & VLAN table and count as 1 x STP instance.

32.33 Module To Transmit Protection Commands

This Module shall support the following features related to the Protection Commands:

i) Transmit 4 Protection Commands bi - directionally. Each Command shall be programmable for permissive, blocking or direct trip functions

ii) Accept Protection Command Signals in the Range of 24 V DC … 250 V DC (Site Programmable) directly from Station Battery without involving any intermediate Converter.

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iii) All inputs and outputs shall be independent and be isolated and with EMC immunity for harsh environment.

iv) Security and Dependability shall be selectable and programmable.

v) It shall also be able to drop and insert Commands, transfer Commands as a transit station and to realize AND - and OR - combinations between commands.

The Tele Protection Module shall provide:

i) An Integrated Non-Volatile Event Recorder, which shall synchronize either internally or by external Global Positioning System (GPS) Clock.

ii) A command counter, which counts trip commands.

iii) Proposed Teleprotection equipment should support management from centralized NMS.

iv) Signal Delay Measurement

v) 1 + 1 Protection, Switching shall be done within less than 4 ms (typical value)

vi) Periodically Automatically Initiated Loop - Tests (e.g. every 60 s).

vii) Command Addressing: This function shall be used to prevent tripping if the signal is inadvertently re - routed through the Telecommunication Network

viii) Under no circumstances, will the Module cause Trip - Commands in case of Power Supply Failure or when Equipment is put into or taken out of service.

ix) A command counter, which counts trip Send/Receive, commands.

x) It shall have inbuilt provision for measurement of command transmission time across the link.

xi) It shall support 1+1 protection and auto switching time shall be less than 4 ms.

xii) The transmission path of each command should be monitored by cyclic loop tests. Any Failure in module, system shall be reported in system logs & shall have provision for external alarm contacts.

xiii) Digital protection coupler should be supported with 3 terminal operations.

xiv) It shall have in built non-volatile event-recorder with time stamping.

xv) The tele-protection interface must comply with IEC 60834-1 specifications & be configurable for various protection schemes - Permissive tripping (under / overreaching), Inter tripping (transfer tripping), Blocking / Unblocking and T-off (normal or inverse).

xvi) The transmission path of each command should be monitored by cyclic loop tests. Any Failure in module, system shall be reported in system logs & shall have provision for external alarm contacts.

xvii) There shall also be provision for external digital trip counters for all 4 commands.

xviii) Teleprotection DPC should be supported over SDH as well as MPLS-TP.

xix) DPC should support C37.94 and E1/Ethernet as preferred communication ports.

32.34 Module To Interface Directly With Line Differential Relays (Optical Interface)

This Module shall have 4 Optical Ports, each of them allowing direct connection to Protection Relays with Interfaces complying with IEEE C37.94 Single mode and multimode optics. Each Interface shall support all 12 - Time Slots (12 x 64 kbps) in

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accordance with IEEE C37.94 and transparent 2 Mbps mode as well.

32.35 Optional Module for Transmission of Binary Signals

This Interface shall provide means to transmit Binary Signals and support the following Features:

i) Isolated Inputs and Outputs (I / O)

ii) Accepting I / O for 24 … 60 V DC.

iii) Outputs shall be Numerical Relays.

iv) The Interface shall provide a 24 V DC Auxiliary Power Supply, Short Circuit proof.

32.36 2 M BPS Interface According To ITU - T G.703 AND G.704

This Module shall comply with the ITU - T G.703 / G.704 recommendations and also allow transparent 2 Mbps signals complying with G.703.

The Module shall have at least 4 x 2 Mbps Interfaces, each of which may be individually activated. It shall be possible to have up to 126 x 2 Mbps Interface Modules in a Multiplexer.

Features:

i) Impedance of 120 ohms and 75 ohms

ii) Supporting CRC - 4 multi - frame according to ITU - T G.704 (enabled and disabled by software).

iii) The CAS Signaling according to ITU - T G.704 Table 9 shall be activated optionally.

iv) 2 Mbps Loop - Back of the Incoming Signal as well as the Loop - Back of the Internal Signals.

v) The Interface shall be able to extract the 2.048 MHz Clock for synchronization of the Multiplex Equipment.

32.37 Requirements For Cyber Security

32.37.1 Firmware

It shall be possible to check the integrity/authenticity of the equipment firmware (e.g. through the use of a secure hash or digital signature).

32.37.2 System Time Synchronization

The equipment shall support SNTP client in order to keep the system clock automatically updated.

The equipment shall have the capability to select one of the following operation modes:

32.37.3 Broadcast

The equipment listens for broadcast messages delivered by the SNTP server.

32.37.4 Unicast

The equipment queries periodically the SNTP server. The polling period must be configurable.

32.37.5 Disabled

The SNTP client is disabled. In this case the equipment shall ignore SNTP messages.

The equipment shall have the capability of using a primary and a secondary SNTP

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server when working in Unicast mode. In case the primary server is not available the secondary server will be used.

32.37.6 Interfaces Used to Access The Management Agent

The equipment shall make provision for an Ethernet port (henceforth called "local management interface") that allows access only to the local management agent (i.e. to the management agent running on the equipment itself but not to management agents running on remote equipment).

The equipment shall make provision for interface(s) that allow access to the management agent from a remote site through an IP network (henceforth called "routed management interface(s)").

The equipment shall make provision for a VLAN dedicated exclusively to the traffic to/from the management agent (out-of-band management). The VLAN identification must be configurable.

The priority of the traffic flowing through the routed management interfaces shall be configurable (i.e. capability to assign a Class of Service to the management traffic).

It shall be possible to enable/disable the local management interface by configuration.

It shall be possible to enable/disable the routed management interface(s) by configuration.

The IP address of the local management interface shall be configurable.

The IP address/addresses of the routed management interface(s) shall be configurable.

The local management interface shall not participate in dynamic routing protocol (i.e. the local interface and its IP address are not propagated outside the local equipment).

It shall be possible for a routed management interface to participate in a dynamic routing protocol. The participation shall be configurable.

PROTOCOLS USED TO ACCESS THE MANAGEMENT AGENT

The equipment shall support the following protocols for the communication between the management agent and the network management system (NMS)/craft terminal (CT):

i) Telnet

ii) SSH

iii) IPsec (tunnels between the NMS and the equipment management agent)

iv) SNMPv3

Acceptance of unencrypted communication shall be configurable, i.e. a configurable Boolean variable shall enable/disable acceptance of unencrypted communication.

Acceptance of telnet sessions shall be configurable, i.e. a configurable Boolean variable shall enable/disable acceptance of telnet sessions.

Acceptance of SSH sessions shall be configurable, i.e. a configurable Boolean variable shall enable/disable acceptance of SSH sessions.

Acceptance of SNMP sessions shall be configurable, i.e. a configurable Boolean variable shall enable/disable acceptance of SNMP sessions.

32.38 SYSLOG

The equipment shall support the capability of sending event messages to up to ten different remote syslog servers. Each server is identified by its IPv4 address.

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The UDP port to which the SYSLOG messages are sent shall be configurable for each one of the ten SYSLOG servers.

Enabling generation of SYSLOG messages shall be configurable, i.e. a configurable Boolean variable shall enable/disable the generation of SYSLOG messages.

The equipment shall provide the capability to set the severity threshold for SYSLOG messages sent to a SYSLOG server, i.e. all messages with severity equal or higher than the severity threshold will be sent to the SYSLOG server. Each one of the ten SYSLOG destinations has its own individual settings.

32.39 VLANs

The equipment shall support the capability to do at least the following:

On access ports (ports that connect to end equipment)

i) Reject VLAN tagged frames

ii) Tag VLAN untagged frames

On trunk ports (ports that connect to a remote equipment of the same type specified here)

i) Reject VLAN untagged frames

ii) Forward a VLAN tagged frame only if the VLAN identification matches an entry in a list of explicitly permitted VLAN identifiers

On access trunk ports (ports that connect to a remote equipment not of the same type specified here – the remote equipment sends .1q tagged frames)

i) Reject VLAN untagged frames

ii) Double tag VLAN tagged frames

32.40 Access Control

The equipment shall support at least four network administrator roles. A set of rights (privilege level) as well as a password is associated with each role. The privilege levels will grant the following rights:

i) Role-4 (lowest privilege level)

Typically assigned to administrators that only require monitoring of the network operational status.

ii) Role-3 (Read access only).

Typically assigned to administrators that besides monitoring the network operational status are also required to diagnose malfunctions

Read access and write access to perform diagnostic operations (e.g. counter reset, test loops, etc.).

iii) Role-2 (Typically assigned to the network administrator.)

Read access and write access for all operations with the exception of cyber security related operations.

iv) Role-1 (highest privilege level)

Typically assigned to the security operator.

Read access and write access for all operations including cyber security related operations (e.g. session management, password management, management of RADIUS access server related settings).



A network administrator accessing the equipment management agent shall be subject to authentication.

The equipment shall stop accepting logins for a login retry time after three consecutive unsuccessful login attempts.

The login retry time shall be configurable.

The equipment shall support a session time-out at least for an administrator logged in with Role-1 privilege level.

The equipment shall support both local and remote authentication. For remote authentication the equipment shall support remote RADIUS authentication.

If local authentication is used the equipment shall store the passwords encrypted.

If only remote authentication is used the equipment shall not store the credentials locally (they will be stored on the remote authentication server, i.e. the RADIUS server).

The choice between local, remote or both remote and local authentication shall be configurable. The following options shall be provided:

Enable/Disable local authentication (i.e. against locally stored credentials) on local management interface.

Enable/Disable local authentication (i.e. against locally stored credentials) on routed management interface.

Enable/Disable remote authentication (i.e. RADIUS server) on local management interface.

Enable/Disable remote authentication (i.e. RADIUS server) on routed management interface.

Enable/Disable fall back to local authentication (i.e. against locally stored credentials) if both the primary and secondary RADIUS server (see later requirement) are unavailable.

The equipment shall support a primary and a secondary RADIUS server. If the equipment fails in contacting the primary server it will automatically try to contact the secondary server.

The number of retries to contact the primary RADIUS server before the equipment switches to the secondary RADIUS server shall be configurable.

The time the equipment waits for a reply from the contacted RADIUS server shall be configurable.

The UDP port for the primary RADIUS server shall be configurable.

The UDP port for the secondary RADIUS server shall be configurable.

32.41 Protection Against BC, MC, UU AND KU STORM

The equipment shall provide the capability to limit the ingress rate of Broadcast, Multicast, Unknown Unicast and Known Unicast frames on port basis.

32.42 OSPF Authentication

The equipment shall provide the capability to authenticate OSPF messages (e.g. MD5). This capability shall be provided for both DCN and user traffic OSPF capable routers.

32.43 Encryption

The equipment shall provide the capability to encrypt MPLS-TP traffic (end- to-end tunnel encryption). The encryption shall be provided by a plug-in self-contained unit

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(henceforth designated as "encryption unit") offering the following features:

i) Eight (8x) SFP/SFP+ cages for electrical or optical 1 or 10 Gbit/s Ethernet

ii) AES-256 GCM encryption

iii) Four dedicated and independent (i.e. not shared) encryption engines for each one of four pairs of Encrypted/Unencrypted ports (i.e. the 8x ports are grouped into 4x pairs, for each pair one unencrypted port connects to the trusted zone whereas one encrypted port connects to the untrusted zone – henceforth such a port pair will be designated as "E/U ports-pair")

iv) The 4x E/U ports-pairs shall be in turn grouped into 2x fully independent functional sub-units (2x E/U ports-pairs on each functional unit). Independent means that if one of the two functional sub-units is compromised it shall be possible to continue operation on the remaining sub-unit

v) 1 or 10 Gbit/s wire-speed encryption capability for each encryption engine

vi) Management port dedicated exclusively to the management of the encryption unit

vii) MPLS outer label dependent encryption

viii) Up to 1024x keys to encrypt 1024x LSPs to arbitrary endpoints for each one of the four E/U ports-pairs (total 4x E/U ports-pairs X 1024 = 4096 encrypted LSPs)

ix) Encryption of layer 2 frames (e.g. PTP, ESMC) shall be configurable

x) Encryption of OAM message shall be configurable

xi) PTP packet delay variation compensation

xii) Additionally high quality random numbers for cryptographic keys (e.g. quantum random number generation)

xiii) Tampering protection of solder and component sides of the PCB

xiv) (Printed Circuit Board)

xv) Status LED indicators (at least 2x: one for unit status and one for traffic status)

32.44 Management of the encryption unit

i) NMS (Network Management System) dedicated to the encryption unit. The NMS dedicated to the encryption unit will be henceforth designated as "E-NMS".

ii) E-NMS manages the encryption units

iii) E-NMS generates and distributes master keys for each encrypted tunnel to both tunnel endpoints

iv) E-NMS handles the events, statistical data and alarms generated by the encryption units and has the capability to forward such data to the NMS used to administer the communication network (i.e. the NMS doing all non-encryption unit related management)

v) Local management access (e.g. Ethernet interface to connect a CLI/GUI Craft Terminal).

vi) Local management access: 2x physical interfaces and 2x fully independent management agents – one interface and one management agent for each one of the 2x sub-units

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vii) It must be possible to operate the encryption unit without E-NMS using only local management access

viii) Manual or E-NMS based MPLS tunnel configuration

ix) Manual or E-NMS based master key generation

x) Secured connection between the encryption unit and the E-NMS (e.g. TLS)

xi) Interlock between E-NMS and local management access, i.e. if the encryption unit is under E-NMS management then it is no longer manageable via local management access.

32.45 Teleprotection

The equipment shall provide authenticity, integrity and non-replay verification for both distance and differential protection applications when tele protection is transported over MPLS-TP.

The equipment shall use the NIST approved CMAC-AES256 algorithm.

If the equipment supports more than one WAN (Wide Area Network) channels then each channel shall have its own unique configurable key (e.g. if two WAN channels are supported, let us say WAN-1 and WAN-2, then 2x keys shall be supported: one key is used for the communication over WAN-1 and the other key is used for communication over WAN-2).

The equipment shall generate an alarm if the key in force is the default key.

The equipment shall generate an alarm every time an authenticity/integrity/replay check fails.

The equipment shall keep a local history in non-volatile memory of the failed authenticity/integrity/replay checks.

It shall be possible to read out the local history from the Network Management System.

It shall be possible to read out the local history from the Craft Terminal.

IEC 61850 GOOSE PROTECTION INTERFACE

The equipment shall provide authenticity, integrity and non-replay verification for IEC 61850 GOOSE messages when these messages are transported over MPLS-TP.

The equipment shall use the NIST approved CMAC-AES256 algorithm.

If the equipment supports more than one WAN (Wide Area Network) channels then each channel shall have its own unique configurable key (e.g. if two WAN channels are supported, let us say WAN-1 and WAN-2, then 2x keys shall be supported: one key is used for the communication over WAN-1 and the other key is used for communication over WAN-2).

The equipment shall support MAC address filtering (firewalling) to restrict access to the station bus from the wide area network interface. The approach shall be whitelisting, i.e. an Ethernet frame will be forwarded only if it matches an entry in a list of explicitly permitted MAC addresses.

The equipment shall generate an alarm if the key in force is the default key.

The equipment shall generate an alarm every time an authenticity/integrity/replay check fails.

32.46 Optical Amplifier System

To achieve the distances upto 350 kms, Optical Amplifier Systems shall be proposed along with the STM -1/4/16 or 1G/10G MPLS-TP FOTE System. The Optical

Amplifier System may consist of the following Components:

32.47 Wavelength Converter Unit

The WC shall Interface 1310 nm – Short - Haul Data Transmission Equipment to Optically Amplified Systems. The Line Transmitter and Receivers of the WC Series shall be designed Effective Receiver for Long Haul Transmission Systems

32.48 Optical Booster Amplifier

The Power Amplifier System shall be installed right after the OLTE; it shall provide post amplification of the signal into the Link. The Unit shall provide a saturated output signal power of 10 to 24 dBm.

32.49 Pre-Amplifier

Pre-amplifier shall reconstruct and boost received optical signal. Pre-amplifier shall be integrated or stand-alone type. Shall operate on 48V DC with power supply redundancy.

32.50 Raman Amplifier

The Raman Amplifier System shall consist of Multiplexed Laser Diode Raman Pump Source to provide up to 12 dB of Optical Gain, and 3 - 4 dB of System improvement for Links where extra margin is required. The Unit shall be inserted at the Receive End of the Fibre Link.

32.50.1 Features

i) Data Rates including STM – 1 / OC3, STM – 4 / OC12, and STM – 16 / OC48 and Multi - Rate

ii) Dual Input Power Supply

iii) CRAFT Terminal Interface

iv) Remote Alarm Indication through Dry Contact Relays

v) External Inputs, Reset, Disable

32.50.2 Physical Specifications

i) Package 19” Rack or ETSI Compatible Rack

32.50.3 Equipment Management

i) Craft Terminal Interface Proprietary through RS232 Serial Link or Ethernet interface.

ii) Alarms Outputs Relay Contact for Alarms

iii) External Inputs Emergency Shutdown, Forced Reset

32.50.4 ALS (Automatic Laser Shutdown) Mechanism

The ALS Mechanism shall be implemented on Systems that use Boosters and Pre - Amplifier. On the presence of a Fibre Cut or Fibre Degradation, a LOS shall be detected on the Pre - Amplifier and, through an Ethernet Switch used to connect the Equipment to the Management System; it shall send a Tele Command to reduce by 30 % the Booster Output Power. In this situation the Pre - Amplifier, on the other Station, will also detect a LOS and reduce the Booster Output Power. After the Fibre Restoration is done, the Pre - Amplifiers should be put at their Nominal Output Power through the Management Network and the System would return to normal operation.

This Mechanism can be enabled or disabled through the Management System. These Optical Amplifier Systems shall be 19” Rack mountable or Din Rail mountable and of 1U height

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Bidder shall design the Optical Amplifier System as per the Distances and Optical Power Budget Link Calculations shall be furnished with the Bid.

Bidder must submit Optical Power Budget Calculation Sheet. In line with following link budget parameters:

i) Fibre attenuation: The fibre attenuation shall be taken to be the guaranteed maximum fibre attenuation i.e. 0.21 dB/Km @1550nm and 0.35 dB/km @1310nm.

ii) Splice loss: Minimum 0.05 dB per splice. One splice shall be considered for every 3 kms.

iii) Connector losses: Losses due to connectors shall be considered to be minimum 1.0 dB per link.

iv) Equipment Parameters: The equipment parameters to be considered for link budget calculations shall be the guaranteed "End of Life (EOL)" parameters. In case, the End-of-Life parameters are not specified for the SDH equipment, an End-of-Life Margin of at least 2 dB shall be considered and a similar margin shall be considered for optical amplifiers.

v) Optical path Penalty: An optical path penalty of at least 1 dB shall be considered to account for total degradations due to reflections, inter symbol interference, mode partition noise and laser chirp.

vi) Maintenance Margin: A maintenance margin of at least 2.5 dB/100Km shall be kept towards cabling, repair splicing, cable ageing and temperature variations etc.

vii) Other losses: Other losses, if any required specifically for system to be supplied shall also be suitably considered.

viii) Dispersion: The fibre dispersion shall be taken to be the guaranteed maximum dispersion i.e. 18 ps/nm.km @1550 nm & 3.5 ps/nm.km @ 1310 nm for DWSM fibres.

ix) Bit Error Rate: The link budget calculations shall be done for a BER of 10-10.

32.51 Electronic Private Automatic Exchange (EPAX)

The 24 Line Electronic Private Automatic Exchange (EPAX) wherever specified shall be connected to Multiplexer with Four Wire E / M Interface Unit. The Exchange will have its own Ringing Current and Tone Generator etc. The Exchange shall be suitable for working on 48 Volt, DC Power Supply (Positive Pole Earthed). The Exchange shall be fully Automatic, Solid State and of Modular Construction and shall have Multiple Switching Routes (Minimum 4 Routes).

System shall be suitable for future upgradable to Voice over IP functionality.

EPAX shall also be provided with Two (2) Additional Interface Units and operate exclusively with Owner's leased Subscribers Lines, of Department of Telecommunication (DOT) and compatible with 2 Wire Full Duplex, Voice Grade Mode of operation. The Detail of Communication Protocol, for interfacing of the DOT Leased Lines shall be coordinated by the Contractor with the Licensing Authority (DOT).

Bidder to consider appropriate leased line with necessary communication accessories, adequate bandwidth for monitoring and control from Tata power System between these stations. Expenses to establish these leased lines along with statutory permission is in bidder's scope.

The system should have the following features / facilities along with standard features

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/ facilities of EPAX.:

i) Day Night feature.

ii) Caller ID features for outside & internal calls.

iii) Must function on both pulse & tone dialling.

iv) Call transfer, Call forwarding & Ring while free on busy.

v) Distinctive ring tones.

vi) Class of service

vii) Group hunting for extension calls & junction lines for outgoing calls.

viii) Hotline.

ix) Wakeup.

x) Digital key telephones should have **hands-free (with speaker & mic), mute & redial facilities and LED indications.**

32.52 Inspection, Test & Availability

All materials furnished and all work performed under this Contract shall be inspected and tested. Deliverables shall not be shipped until all required inspections and tests have been completed, and all deficiencies have been corrected to comply with this Specification and approved for shipment by the Employer.

Except where otherwise specified, the Contractor shall provide all manpower and materials for tests, including testing facilities, logistics, power and instrumentation, and replacement of damaged parts. The costs shall be borne by the Contractor and shall be deemed to be included in the contract price.

The entire cost of testing for factory & site acceptance, routine tests, production tests and other test during manufacture & site activities specified herein shall be treated as included in the quoted unit price of materials, except for the expenses of Inspector/Employer's representative.

Acceptance or waiver of tests shall not relieve the Contractor from the responsibility to furnish material in accordance with the specifications.

All tests shall be witnessed by the Employer and/or its authorized representative (hereinafter referred to as the Employer) unless the Employer authorizes testing to proceed without witness. The Employer representative shall sign the test form indicating approval of successful tests.

Should any inspections or tests indicate that specific item does not meet Specification requirements; the appropriate items shall be replaced, upgraded, or added by the Contractor as necessary to correct the noted deficiencies at no cost to the Employer. After correction of a deficiency, all necessary retests shall be performed to verify the effectiveness of the corrective action.

The Employer reserves the right to require the Contractor to perform, at the Employer's expense, any other reasonable test(s) at the Contractor's premises, on site, or elsewhere in addition to the specified Type, Acceptance, Routine, or Manufacturing tests to assure the Employer of specification compliance.

All security related features shall be demonstrated during FAT/SAT as required by the Employer.

32.53 Inspection

Access to the Contractor's facilities during system manufacturing and testing and to any facility where systems/ equipment are being produced/ tested/ integrated for the fibre

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optic communication network, shall be available to the Employer. At all times the Employer shall have full facilities for unrestricted inspection of such materials or equipment. To facilitate this, the Contractor shall submit for the Employer approval, a comprehensive Quality Assurance Plan using ISO 9000 as a general guideline. In addition, the Quality Assurance Plan shall satisfy the following:

i) Sufficient office facilities, equipment, and documentation necessary to complete all inspections and to verify that the equipment is being fabricated and maintained in accordance with the Specification shall be provided by the Contractor to the Employer.

ii) Inspections to be performed by the Employer will include visual examination of hardware, cable dressings and labelling. Contractor's documentation will also be examined to verify that it adequately identifies and describes all offered items and spare parts.

iii) Access to inspect the Contractor's standards, procedures and records that are applicable to the supplied equipment shall be provided to the Employer. Documents will be inspected to verify that the Contractor has performed the required quality assurance activities.

iv) The inspection rights described above shall also apply to sub-Contractors who are responsible for supplying major components described in this Specification. To shall be inspected and tested at the sub-Contractor's factory by the Employer's representatives prior to shipping this equipment to the Contractor's facility or directly to the Employer.

v) The above inspection rights shall also apply to sub-Contractors supplying assemblies, subassemblies, and components. However, such items will normally be inspected and tested by the Employer's representatives at the Contractor's site before acceptance.

32.54 Test Plans and Procedures

Test plans and test procedures for both factory and site acceptance tests shall be provided by the Contractor. Test plans and test procedures shall features of the equipment to be tested. Test plans and test procedures shall be modular to allow individual test segments to be repeated upon request.

The Contractor shall submit a Test Schedule for the Employer's approval The test schedule shall list the tests to be carried out, and the approximate test duration. The test periods shall also be indicated in the PERT chart or equivalent for the work.

The Contractor shall give the Employer prior written notice of any material being ready for testing. Employer shall provide written notice to the Contractor of any drawings, equipment, material, or workmanship which, in the Employer's opinion, are not compliant to the specification. The Contractor shall give due consideration to such objections, if valid, effecting the corrections as necessary or shall prove, in writing, that said modifications are not necessary for contract compliance.

32.54.1 Factory and Site Test Plans

A test plan for factory and site acceptance tests shall be submitted for approval, before the start of testing. The test plan shall be a single overview document that defines the overall schedule and individual responsibilities associated with conducting the tests, documenting the test results, and successfully completing the test criteria. Test Plans shall include, at a minimum, the information contained in table below:

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Factory & field Test Plan Requirements	
Item	**Description**
1.	Test schedule
2.	Record-keeping assignments, procedures and forms
3.	Procedures for monitoring, correcting and retesting variances
4.	Procedures for controlling and documenting all changes made to the communications equipment after the start of testing

32.54.2 Test Procedures

Test procedures for factory and site testing shall be submitted for the Employer approval before each individual test. Fully approved test procedures shall be submitted to the Employer prior to the commencement of testing. Testing shall not commence without approved test procedures. At a minimum, test procedures shall include the items listed in Table below:

Test Procedure Requirements	
Item	**Description:**
1.	Test Title and Revision Level, if applicable
2.	List of Standard(s) complied with
3.	Function(s) / parameter(s) to be tested
4.	Purpose of each test segment
5.	List of required test equipment
6.	Description of any special test conditions or special actions required. This includes complete descriptions, listings and user interface procedures for all special hardware and software tools and/or display formats to be used during the test
7.	Test setup including test configuration block diagrams and/or illustrations
8.	Test procedures to be followed.
9.	Required inputs and expected outputs for each test segment
10.	Acceptance criteria for each test segment.
11.	List of test data to be supplied by the Contractor(s) and copies of any certified data to be used
12.	Format of test reports

All test equipment and/or instruments shall bear calibration stickers indicating valid calibration on and beyond the testing date. The time lapsed since last calibration shall not exceed the test equipment/ jig manufacturer recommended calibration interval or the interval recommended in the test lab's internal quality procedures.

The Contractor shall ensure that all testing will be performed by qualified testing personnel well experienced in performing such tests.

32.54.3 Test Records

Complete and indexed records of all factory and site acceptance tests results shall be maintained and provided to the Employer by the Contractor in hard and soft copy. The records shall be keyed to the steps enumerated in the test procedures. The minimal items required in test records are described in Table

Test Record Requirements

Sl. No.	Description
1	Test Title and Revision Level, if applicable; contract references
2	Date and time for test start and test completed
3	Test title and reference to the appropriate section of the test procedures
4	Description of any special test conditions or special actions taken (Includes test-case data).
5	Test results for each test segment including an indication of Passed, Conditional Pass, Incomplete or Failed.
6	Test procedure modifications made during testing.
7	Variance Report(s) tracking information and copies (if variance(s) was detected).
8	Contractor's test engineer(s) identification, signature and remarks
9	Employer's test witness identification, signature and remarks
10	List of all attachments
11	Attachments (including system logs, printouts, variances, hard copies of visual test result displays, etc.)

All principle test records, test certificates and performance curves shall be supplied for all tests carried out as proof of compliance with the specifications and/or each and every specified test. These test certificates, records and performance curves shall be supplied for all tests, whether or not they have been witnessed by the Employer within the specified duration after the completion of test. Information given on such test certificates and curves shall be sufficient to identify the material or equipment to which the certificates refer and shall also bear the Contractor's reference and heading.

32.54.4 Rejection of Elements

Any item or component which fails to comply with the requirements of this Specification in any respect, at any stage of manufacture, test, erection or on completion at site may be rejected by the Employer either in whole or part as considered necessary.

Material or components with defects of such a nature that do not meet the requirements of the Specification by adjustment or modification shall be replaced by the Contractor at his own expense. After adjustment or modification, the Contractor shall submit the items to the Employer for further inspection and/or tests.

32.54.5 Test Periods Defined

The terminology used in General Conditions of Contract and their correlation with the tests requirements described is as follows:

Pre-Commissioning & Commissioning Period - The Site Acceptance Test (SAT)

Operational Acceptance - Successful completion of SAT

32.54.6 Type Testing

"Type Tests" shall be defined as those tests which are to be carried out to prove the design, process of manufacture and general conformity of the materials to this Specification. Type Testing shall comply with the following:

i) All equipment being supplied shall conform to type tests as per technical specification.



ii) The test reports submitted shall be of the tests conducted within last five (5) years prior to the date of bid opening. In case the test reports are older than five years (5) ago on the date of bid opening, the Contractor shall repeat these tests at no extra cost to the Employer.

iii) The Contractor shall submit copies of test reports for all of the Type.

iv) Tests that are specified in the specifications and that have previously (before Contract award) been performed. These reports may be accepted by the Employer only if they apply to materials and equipment that are essentially identical to those due to be delivered under the Contract and only if test procedures and parameter values are identical to those specified in these specifications, carried out at accredited labs and witnessed by third party/customer's representatives.

v) In the event of any discrepancy in the test reports or any type tests not carried out, same shall be carried out by Contractor without any additional cost implication to the Employer.

vi) Type Tests shall be certified or performed by reputed laboratories using material and equipment data sheets and test procedures that have been approved by the Employer. The test procedures shall be formatted as defined in the technical specifications and shall include a complete list of the applicable reference standards and submitted for Employer approval before commencement of test(s). The Contractor shall provide the Employer written notice of the planned commencement of each type test.

vii) The Contractor shall provide a detailed schedule for performing all specified type tests. These tests shall be performed in the presence of a representative of the Employer.

viii) The Contractor shall ensure that all type tests can be completed within the time schedule offered in his Technical Proposal.

ix) In case of failure during any type test, the Supplier is either required to manufacture a fresh sample lot and repeat all type tests successfully or repeat that particular type test(s) at least three times successfully on the samples selected from the already manufactured lot at his own expenses. In case a fresh lot is manufactured for testing then the lot already manufactured shall be rejected.

32.54.7 Type Test Samples

The Contractor shall supply equipment/material for sample selection only after the Quality Assurance Plan has been approved by the Employer. The sample material shall be manufactured strictly in accordance with the approved Quality Assurance Plan. The Contractor shall submit for Employer approval, the type test sample selection procedure. The selection process for conducting the type tests shall ensure that samples are selected at random. At least three samples of each of the proposed equipment shall be offered for selection, out of which one sample for each equipment shall be selected.

32.54.8 List of Type Tests

The type testing shall be conducted on the following equipment

i) SDH – Synchronous Digital Hierarchy Equipment with all types of cards

ii) PDH – Plesiochronous Digital Hierarchy with subscriber interface card

iii) Digital Protection Coupler - DPC

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32.54.9 List of type test to be conducted on telecom equipment.

The type tests for SDH Equipment with all types of cards, Multiplexer with Temperature and Humidity Tests

i) The tests listed below are defined in IEC Publication 60068.

ii) Low Temperature Test: Operation to Specifications

Low temperature tests shall be conducted as defined in IEC Publication 60068-2-1, test method Ad, with the following specifications:

i) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for sixteen (16) hours. Its performance is checked during the test.

ii) Degree of Severity: Test shall be done at 0°C

iii) Acceptance Criteria: No degradation of performance during and after the test.

iv) Low Temperature Test: Operation without Damage

Low temperature tests shall be conducted as defined in IEC Publication 60068-2-1, test method Ad, with the following specifications:

i) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 72 hours. Its performance is checked during the test and after the test as soon as the thermal equilibrium is reached at the room temperature (Post-test).

ii) Degree of Severity: Test shall be done at -10° C

iii) Acceptance Criteria: Degradation of performance is allowable during the test, however there shall be no degradation of performance in the post-test.

Dry Heat Test: Operation to Specifications

Dry heat test shall be done as defined in IEC Publication 60068-2-2, test method Bd, with the following specifications:

i) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 96 hours. Its performance is checked during the test.

ii) Degree of Severity: As per table below: operation to specification range.

iii) Acceptance Criteria: No degradation of performance during and after the test.

iv) Dry Heat Test: Operation without Damage

Dry heat tests shall be done as defined in IEC Publication 60068-2-2, test method Bd, with the following specifications:

i) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 96 hours. Its performance is checked during the test and after the test as soon as the thermal equilibrium is reached at the room temperature (Post-test).

ii) Degree of Severity: Test shall be done at 55ºC.

iii) Acceptance Criteria: Degradation of performance is allowable during the test, however there shall be no degradation of performance in the post-test.

iv) Damp Heat Test

Damp heat testing reveals aging with respect to the humidity level and applies basically to electronic equipment. This test shall be done as defined in IEC Publication 60068-2-

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3 with the following specifications:

i) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 10 days. Its performance is checked during the test.

ii) Degree of Severity: Test shall be done at (40 ± 2) °C & (93 ± 3)% RH

iii) Acceptance Criteria: The equipment shall meet the specified requirement and there shall not be any degradation in BER.

iv) Temperature Variation Test

Temperature variation testing shall be as per IEC Publication 600682-14 (Gradual Variations, Method Nb). The equipment shall be powered on and various parameters shall be monitored continuously during the test period.

i) Number of cycles required is five (5)

ii) The degree of severity: temperature TL:0°C, TH: As per table Operation to specification range

iii) Cycle duration for each temperature is three (3) hours.

iv) Ramp: 1°C/minute.

v) Acceptance Criteria: The equipment shall meet the specified requirement and there shall not be any degradation in BER.

Water Penetration Test:

FO cables must meet the requirement of Water penetration test conducted as over the cable core as per the following

Test Conditions: Sample Length: 3m

i) Water head :1 m.

ii) Duration :24 hours.

Acceptance Criteria:

There shall be no water from the other end of the cable after 24 hrs.

i) DRIP Test:

On 30cm cable sample with one end sealed by the end cap, remove PE sheath, Armour, binders and tapes etc, upto 5cms at the other end and clean all the jelly. Then keep the sample vertically in the oven at 70deg.c for 25hrs with a paper under the sample.

Acceptance criteria: There shall not be any oil impression or jelly drip on the paper after 24hrs.

32.54.10 Power Supply and EMI/EMC tests

The test procedure and acceptance criteria shall be as defined in IEC 608702-1

i) Immunity Tests

ii) Emission Tests

iii) Insulation Withstand Voltages

Sr. No.	Immunity Test	AC Power Supply	DC Power Supply	Control Signal	Telecom Line	Parameters
1	Voltage Fluctuations	Yes	Yes	N/A	N/A	Table 11 of IEC 60870-2-
2	Voltage dips &	Yes	Yes	N/A	N/A	

	Interruptions					1 - Level : 1
3	1.2/50 - 8/20 µs surges	Yes	Yes	Yes	N/A	Table 12 of IEC 60870-2-1 - Level: 4
4	Fast transient bursts	Yes	Yes	Yes	Yes	
5	Damped oscillatory waves	Yes	Yes	Yes	Yes	
6	10/700 µs surges	N/A	N/A	N/A	Yes	
7	Electrostatic discharge	Yes				Table 13 of IEC 60870-2-1 - Level: 4
8	Power frequency magnetic field	Yes				Table 14 of IEC 60870-2-1 - Level : 4
9	Damped oscillatory magnetic field	Yes				
10	Radiated electromagnetic field	Yes				Table 15 of IEC 60870-2-1 - Level : 4
11	Power Frequency voltage on control and signal lines	N/A	N/A	Yes	Yes	IEC 61000-4-16 - Level : 4
12	DC voltage on control and signal lines	N/A	N/A	Yes	N/A	IEC 61000-4-16 - Level : 4
13	LF disturbance voltages CCITT recommendation P.53	N/A	Yes	N/A		C 60870-2 -1 - Class : B
14	RF disturbance voltages CISPR 22	Yes	Yes	N/A		
15	RF disturbance currents CISPR 22	N/A	N/A	Yes		
16	RF radiated fields CISPR 22	Yes				
17	LF disturbance voltages CCITT recommendation P.53	N/A	Yes	N/A		
18	RF disturbance voltages CISPR 22	Yes	Yes	N/A		
19	RF disturbance currents CISPR 22	N/A	N/A	Yes		

32.54.11 Mechanical Tests

Mechanical Vibration Test

The procedure for this test is described in IEC Publication 60068-2-6.

The testing procedure shall be carried out in the sequence 8.1 + 8.2.1 + 8.1 as described in document 60068-2-6.

For the vibration response investigation (clause 8.1 of 60068-2-6), the test shall be carried out over a sweep cycle under the same conditions as for the endurance test (described later), but the vibration amplitude and the sweep rate may be decreased below these conditions so that the determination of the response characteristics can be obtained.

The endurance test conditions are selected according to the vibration withstand requirements.

Transportation tests shall be performed with the equipment packed according to the Contractor's specifications.

Shock Test

The procedure of this test is defined in IEC Publication 60068-2-27 (each test) with a semi- sinusoidal shape (clause 3.1.1.2).

The recommended severity shall be A = 294 m/s2, D = 18 ms. Three shocks per axis per direction shall be applied to the equipment packed according to the contractor's specifications.

Free Fall Test

This test could be performed as an alternative to the shock or Bump test. The procedure is defined in IEC publication 60068-2-32. The equipment shall be packed according to the Contractor's specifications. The drop height shall be defined in accordance with IEC 68-2-32. The surface of the packing case which comes into contact with the ground is the surface on which the packing case normally rests; if the packing does not have any features (inscription, special shape, etc.) identifying this surface, the test is carried out successively on all the surfaces of the packing.

Bump Test

This test could be performed as an alternative to Shock test or Free Fall test. The procedure is defined in IEC 60068-2-29.

Types Tests to be conducted on Digital Protection Coupler

General equipment interface tests:

i) Insulated voltage withstand tests

ii) Damped oscillatory waves disturbance test

iii) Fast transient bursts disturbance test

iv) Electrostatic discharge disturbance test

v) Radiated electromagnetic field test

vi) RF disturbance emission test

32.54.12 Specific power supply tests

i) Power supply variations

ii) Interruptions

iii) LF disturbance emission

iv) Reverse polarity

32.54.13 Tele-protection system performance tests

i) Security

ii) Dependability

iii) Jitter

iv) Recovery time

v) Transmission time

vi) Alarm functions

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vii) Temperature and Humidity tests (As per IEC 68-2)

viii) Dry heat test (50°C for 8 hours)

ix) Low temperature test (-5°C for 8 hours)

x) Damp heat test (40°C/95%RH for 8 hours)

All the above tests at (except temperature & humidity tests) shall be as per IEC 60834-1 and the standards mentioned therein.

32.54.14 Relays

i) Impulse voltage withstand test as per clause 6.1 of IS:8686 (for a test voltage appropriate to clause III as per clause 3.2 of IS:8686)

ii) High frequency disturbance test as per clause 5.2 of IS:8686 (for a

iii) test voltage appropriate to clause III as per clause 3.2 of IS:8686)

The protection signalling equipment shall be of modular construction and preferably mounted in the Relay panels. Cabling between the protection signalling equipment & Protection relays and between protection signalling equipment & Communication equipment shall be in the scope of bidder.

The input/output interface to the protection equipment shall be achieved by means of relays and the input/output rack wiring shall be carefully segregated from other shelf/cubicle wiring.

The isolation requirements of the protection interface shall be for 2kV rms.

32.54.15 Factory Acceptance Tests

Factory acceptance tests shall be conducted on randomly selected final assemblies of all equipment to be supplied. Factory acceptance testing shall be carried out on SDH Equipment, associated line & tributary cards, Termination Equipment (Primary Mux, Drop/Insert, DACS, associated Subscriber Line Interface Cards etc), Network Management System, Digital Protection Coupler, DCPS, Battery etc. and all other items for which price has been identified separately in the Bid Price Schedules.

Equipment shall not be shipped to the Employer until required factory tests are completed satisfactorily, all variances are resolved, full test documentation has been delivered to the Employer, and the Employer has issued Material Inspection & Clearance Certificate (MICC). Successful completion of the factory tests and the Employer approval to ship shall in no way constitute final acceptance of the system or any portion thereof. These tests shall be carried out in the presence of the Employer's authorized representatives unless waiver for witnessing by Employer’s representatives is intimated to the contractor.

Factory acceptance tests shall not proceed without the prior delivery to and approval of all test documentation by the Employer.

The factory acceptance test shall demonstrate the technical characteristics of the equipment in relation to these specifications and approved drawings and documents. List of factory acceptance tests for Fibre Optic Transmission system, Termination Equipment Sub-system, NMS, DCPS and Battery are given in specified Tables. This list of factory acceptance tests shall be supplemented by the Contractor's standard FAT testing program. The factory acceptance tests for the other items shall be proposed by the Contractor in accordance with technical specifications and Contractor's (including Subcontractor’s / supplier's) standard FAT testing program. In general the FAT for other items shall include at least: Physical verification, demonstration of technical characteristics, various operational modes, functional interfaces, alarms and diagnostics etc.

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For Test equipment & clock, FAT shall include supply of proper calibration certificates, demonstration of satisfactory performance, evidence of correct equipment configuration and manufacturer's final inspection certificate/ report.

32.54.16 FAT

FAT to be carried out on 100% active equipment's offered. Integrated (Hardware and Software) FAT shall be carried out by bidder at OEM factory for DCS Protection, Automation and Communication system.

The Bidder shall submit a test specification for factory acceptance test (FAT) and commissioning tests of the Communication System for approval. Bidder to submit the type test certificates, pre-FAT testing reports and document before the start of FAT at Vendor's works. The manufacturing phase of the Communication system shall be concluded by the factory acceptance test (FAT). The purpose is to ensure that the Vendor has interpreted the specified requirements correctly and that the FAT includes checking to the degree required by the user. The general philosophy shall be to deliver a system to site only after it has been thoroughly tested and its specified performance has been verified, as far as site conditions can be simulated in a test lab.

During FAT the entire System including complete control and protection system to be supplied under present scope shall be tested for complete functionality and configuration in factory itself. The extensive testing shall be carried out during FAT. The purpose of Factory Acceptance Testing is to ensure trouble free installation at site. No major configuration setting of system is envisaged at site.

Since FAT testing provides a measure of assurance that the Quality Control objectives are being met during all phases of production, the Employer reserves the right to require the Contractor to investigate and report on the cause of FAT failures and to suspend further testing/ approvals until such a report is made and remedial actions taken, as applicable.

32.54.17 Production Testing

Production testing shall mean those tests which are to be carried out during the process of production by the Contractor to ensure the desired quality of end product to be supplied by him. The production tests to be carried out at each stage of production shall be based on the Contractor's standard quality assurance procedures. The production tests to be carried out shall be listed in the Manufacturing Quality Plan (MQP), along with information such as sampling frequency, applicable standards, acceptance criteria etc.

Sl. No.	Description
1	Physical inspection for conformance to DRS, BOQ, drawings and appearance of equipment
2	Optical output power
3	Transmitter light wave spectral analysis
4	Low receive level threshold
5	Generation of bit error rate curve
6	Measurement of analog and digital service channel parameters as well as service channel functionality
7	Performance of supervision, alarm, Craftsperson interface, diagnostics, loop backs etc.
8	Electrical interface tests which include output and input jitter,

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	bit error rate, pulse shape, cable compensation and line rate tolerance for multiplexers
9	At a minimum test on Ethernet interface shall include demonstration of ping test, throughput test, Latency test, Packet Loss test as per RFC 2544
10	Simulation of failure conditions and failover of each redundant unit.
11	VLAN (Layer-2 switching) feature testing with at least three equipment configurations
12	Protection scheme for Ethernet Traffic (ERPS)
13	Test of spare card slots
14	Checks of power supply/converter voltage margins
15	Random inspections to verify the accuracy of documentation
16	Test of spare parts/modules/cards as per applicable tests

32.54.18 Site Acceptance Tests

The Contractor shall be responsible for the submission of all equipment & test equipment supplied in this contract for site tests and inspection as required by the Employer. All equipment shall be tested on site under the conditions in which it will normally operate.

The tests shall be exhaustive and shall demonstrate that the overall performance of the contract works satisfies every requirement specified. At a minimum Site Acceptance Testing requirement for Telecom equipment etc. is outlined in following section. This testing shall be supplemented by the Contractor's standard installation testing program, which shall be in accordance with his quality plan(s) for Telecom equipment installation.

During the course of installation, the Employer shall have full access for inspection and verification of the progress of the work and for checking workmanship and accuracy, as may be required. On completion of the work prior to commissioning, all equipment shall be tested to the satisfaction of the Employer to demonstrate that it is entirely suitable for commercial operation

32.54.19 Phases for Site Acceptance Testing:

The SAT shall be completed in following phases:

32.54.20 Installation Testing

The field installation test shall be performed for all equipment at each location. If any equipment has been damaged or for any reason does not comply with this Specification, the Contractor shall provide and install replacement parts at its own cost and expense.

In the installation test report, the Contractor shall include a list of all hardware or components replaced or changed between the completion of factory tests and the start of field tests and show that documentation and spare parts have been updated.

The minimal installation testing requirements for Fibre optic transmission subsystem, Termination equipment sub-systems are provided in respective Tables.

32.54.21 Link Commissioning Tests

The commissioning tests shall verify that communication can be performed over the Fibre optic link under test. Delay measurement, Bit Error measurements & service channel performance monitoring shall be made on the fibre optic links to verify

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compliance with designed link performance.

For Ethernet interface: At a minimum the following test requirements shall be demonstrated as per RFC 2544:

i) Ping test

ii) Throughput test

iii) Latency test

iv) Packet Loss

VLAN (Layer-2 switching) feature testing with equipment as per network configuration shall be demonstrated.

10% of the total communication links (Chosen by the Employer, generally to cover links from all configurations used) shall be tested for a duration of 12 Hours.

Rest of the links shall be tested for 1 Hour. In case a link does not meet the performance requirements during 1 hour, then the duration of the test shall be increased to 12 hours.

In case any link does not meet the performance requirements during 12 hour, then the cause of failure shall be investigated and the test shall be repeated after rectifying the defects.

This phase of testing shall be conducted by the Contractor and witnessed by the Employer. Field adjustments shall be made to meet established standard, however if the field adjustments fail to correct the defects the equipment may be returned to the Contractor for replacement at his own expense. In case any adjustments are required to be made during the interval of the test then the test shall be repeated.

32.54.22 Integrated Testing

Prior to commencement of integrated testing the overall system shall be configured as required to provide all the data and voice channel required to interconnect the various control centres and RTU. The integrated testing for a batch shall include end-to-end testing of back-bone network included in that batch. Integrated testing for last batch shall include testing of the entire back- bone. The intent of integrated testing is to demonstrate that the equipment is operational end to end under actual conditions, that all variances identified during factory and field installation and communications testing have been corrected, and that the communication equipment is compatible with other equipment at all locations. The Integrated System Test shall include all fibre optic transmission equipment, termination equipment, the network management subsystem and other components.

At a minimum the following tests shall be included in the integrated testing:

i) Equipment configuration shall be checked to establish that it supports the channel routing.

ii) End to end testing of all individual voice circuits originating from PLCC, PABX or Phones and to establish proper interfacing with PLCC\PABX\Phones and to demonstrate proper operation of channels over wideband systems. Operation shall be checked in terms of quality of voice, call initiation and call termination processes. The requirements for integrated testing for PABX system is described separately.

iii) End-to-end testing of all individual Data Circuits originating from PLCC, RTU and SCADA Front Ends and to establish proper interfacing with PLCC\RTU\Front End and to demonstrate proper operation of channels over wideband systems. Operation shall be checked in terms of monitoring of BER/packet loss.



iv) Demonstration of Protection switching and synchronization of equipment as per synchronization plan.

	Fibre Optic Transmission System Installation Testing
Sl. No.	**Description**
1	Physical Inspection for conformance to drawings, rack elevations and appearance of equipment and cabling
2	Station power supply input and equipment power supply (DC-DC converter) output voltage measurements
3	Terminal transceiver performance testing (Tx power, Tx spectrum, receive signal strength, connector losses etc.)
4	Service channel performance
5	Craftsperson interface, alarm and control functional performance
6	Rack and local alarms: No alarms shall be present and all alarms shall be demonstrated to be functional
7	Network management interface and supervision performance
8	Correct configuration, level setting & adjustments and termination of Input/ output interfaces
9	Proper establishment of Safety and signaling earthing system and resistance to ground to be checked.
10	Simulation of failure conditions and failover of protected components.
	Termination Equipment Sub-System Installation Testing
Sl. No.	**Description**
1	Physical Inspection for conformance to drawings, rack elevations and appearance of equipment and cabling
2	Power supply/converter voltage measurements
3	Muldem performance testing
4	Craftsperson interface, alarm and control functional performance
5	Rack and Local alarms
6	Network management interface and supervision performance
7	Channel performance
8	Safety and signalling earthing system
9	Simulation of failure conditions and failover of protected components.

32.55 Fibre Optic Cable

Fibre optic cables of the underground, special and approach types such as wrap around fibre optic cable as required in Data Sheets shall be offered.

For each type of cable offered, Bidder shall provide matching accessories for special tools for cutting, splicing, terminating etc.

Fibre optic cables intended to be used for inside premises application or short distance premises environment should satisfy with GR-409 CORE manufacturing standard.

Fibre optic cables intended to be used for outside plant application or Long Haul/distance environment should satisfy with GR-20 CORE manufacturing standard.

Single Mode fibres and Multimode fibres offered should satisfy EIA / TIA standards.

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32.56 Under Ground Fibre Optic Cable Constructional details:

Fiber packaging: The Fibers are protected inside the jelly filled loose tubes made of PBT. Outer Diameter of the Loose tube is 2.2+/-0.1mm nominal.

Strength Members: The cable has Central Strength Member made of FRP rod of nominal diameter 2.7mm.

Cable Core: The loose tubes are stranded over FRP central Strength member and then binded with suitable binders to hold the tubes intact. All the interfaces of the cable core are filled with Thixotropic Flooding Jelly to make the cable watertight. Over this the polyester tape is applied helically to keep the jelly intact. PE filler can be used to keep the roundness of the core cable.

Inner Cable Sheath: Inner Sheath is provided to protect the cable core with a appropriate nominal thickness.

Armouring: Over this inner Sheath ECCS tape Armouring is required to be done longitudinally to make the cable termite and rodent resistant. The Tape should be electrically continuous throughout its length.

Outer Cable Sheath: Over the Corrugated steel tape Armour Outer HDPE sheath is provided with a nominal 1.80mm thickness.

Attenuation: Every individual fiber of the cable shall have maximum attenuation of 0.36dB/km at 1310nm and 0.22DB/Km at 1550nm.

Printing Detail: Following information must be printed on cable

Name of Supplier, Tata Power Co., SM96F, FOP, Laser Symbol, Telephone Symbol, Month and year of manufacture, Length marking

Rip Cord: Cable should have two rip cord of twisted yarn type under sheath.

Drawings: Vendor shall provide detail drawings of the quoted cable construction along with all dimensions and material used.

32.57 Mechanical & Environmental test requirements

The cable must meet the mechanical and environmental tests as per the IEC test procedures listed in the table below.

After each mechanical test described in the specifications table, the change in attenuation shall be <=0.05dB/Km for each individual fiber without any visible cracks, damage or kink to the cable.

For temperature cycling test ,the attenuation change throughout the cycle ,at every stage shall be <=0.05dB/Km for each individual fiber ,with reference to the reading at room temperature.

32.58 Spares

20 % spares to be supplied on all communication package offered.

Bidder shall submit a list of spares recommended by OEM for a period of 5 years of service.

Essential spares are those considered necessary by the owner for first five (5) years of normal sub-station operation. When a particular item of spares is indicated as `percentage', it shall be considered as percentage of total number of that item of spares in the single equipment/system, unless specified otherwise and the fraction shall be rounded-off to the next higher whole number. Whenever the item of spares has been indicated as `set' the same shall mean the supply for a single equipment/system. One set of spares for the particular equipment shall mean the total quantities of that particular spares for a single equipment e.g., `set' of Server, set of Gateway, shall

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include HMI, keyboard, mouse etc. The `set' shall however include all components required to replace that item of spares. The Owner reserves the right to buy any of the essential spare parts as considered necessary.

In case during start-up and commissioning certain essential spares are used up, the same shall be replaced within one (1) month without any commercial implications.

The spares supplied shall be strictly interchangeable with parts for which they are intended for replacement.

The spares shall be treated and packed for long storage (minimum 5 years) under the climatic conditions prevailing at the site.

The start-up spares are those spares which will be required during start-up and commissioning of the equipment/systems, and until Final Take Over. It is the responsibility of the bidder to supply all the necessary spares as required until the equipment/systems are handed over to the Owner. An adequate stock of start-up spares shall be available at the site such that the start-up and commissioning of the equipment/systems, performance testing and handing over the equipment/systems to the Owner will be carried out without hindrance and delay. All start-up spares which remain unused after the taking over the sub- station shall remain the property of the Owner. The Bidder shall furnish the Schedule of Start-up Spares.

The start-up spares shall be delivered at the site well in time before the start-up and commissioning of the plant.

Jointing kits for fibre optic cables with all necessary accessories like cassettes, splice protector for jointing of 96 fibres cable jointing.

Wall mounted type Termination kits for above fibre optic cable with all necessary accessories like cassettes, pigtails, and coupler for 96 core fibre cable termination along with mounting frame.

32.59 Special Tools & Tackles

Bidder to consider and supply special tools and tackles required for erection, commissioning, and maintenance of the offered system. After commissioning of the system, all tools and tackles shall be handed over to Owner's Project/Maintenance team.

All tools (both hardware and software), test instruments, simulation jigs, documents, programming equipment etc. required for Installation, Testing & Commissioning are in the scope of bidder.

Bidder to consider OTDR- 1 No. (Preferred- EXFO, VIAVI), Splicer 1 No. (Preferred- Fujikura), Power meter 2 Nos (Preferred- EXFO, VIAVI), Visual Fault locator 2 Nos (Preferred- EXFO, VIAVI), ethernet tester 1 No. (Preferred- Fluke) and Tool kit 1 No. (Preferred- RXS, Siemens)

Bidder to consider any other required tools and tackles other than the one mentioned above for system maintenance.

All configuration cables and other specialized testing passive devices to be provided with the supply of material.

Configuration Laptop (min. 2 Nos) to be considered with all necessary software loaded including OS, Office and Management tools with support and subscription of not less than five years. Laptop should be loaded with OEM software for remote and local manageability of all communication devices.

Bidder should offer maintenance and support (AMC) for the entire supplied and installed communication setup for a period of 7 years. Bidder should consider suitable deployment of manpower at site for ensuring availability, day to day activities, breakdowns, O&M, cybersecurity and periodic maintenance activity for systems under

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AMC.

Upgrades & Modifications

Bidder shall continuously keep the Owner informed of all Software and Hardware upgrades as & when these are released.

Bidder shall supply upgrades of all installed software (both own and third party) for a period of five years from the date of system acceptance without any commercial implication.

Bidder shall rectify all design defects and software bugs at no extra cost for a period of 7 years from the date of system acceptance.

Bidder shall provide lifetime support (15 years) for the system, even if no upgrades are implemented.

The system referred to above includes Bidder's own as well as third party components.

Bidder shall port the supplied software onto upgraded hardware (as per Bidder's standard offerings) without additional Software License Fees.

Currency of the equipment

Bidder must offer equipment's which are latest and released not more than 5 years before the date of execution of the contract. The offered equipment should be such that it should not be declared as End of life within period of 15 years from the date of the order execution.

Bidder should submit OEM signed and stamped letter mentioning the following:

Currency of the offered equipment.

Commitment for support for 7 years warranty +7 years post warranty.

System non compromise (Cyber security) compliance since its launch

In case of bidder discontinuing offered system within the warranty period and installed equipment's going faulty and no replacement available. Equipment installed will have replaced by the latest version complying with same specifications at no extra cost to TATA Power.

32.60 Training

The Bidder shall include in his offer Training for Owner engineers. The training shall cover development, integration, installation and commissioning of both software & hardware components of the system.

Bidder to consider 10 man-days training for Owner's personnel along with certification from OEM at OEM labs.

The Bidder shall provide Classroom as well as hands-on training on the system. All required training materials such as system catalogues, test instruments, demo equipment, and simulation jigs, etc. shall be provided by the Bidder. The training shall equip the Owner's engineers for installation, commissioning, operation and post-warranty maintenance of hardware, software (Operating System, Administration and Applications), protocols and all third-party systems.

Factory training shall be immediately prior to FAT. Site Training shall be prior to commissioning on a mutually convenient schedule.

Bidder shall indicate their Training facilities including test tools and simulation facilities. Bidder shall provide the training calendar & details of topics considered for the equipment offered.

Training Requirement

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Bidder shall provide training to the Owner's personnel on the operation and maintenance of the system supplied by him. General requirements relating to the training are specified below:

i) Personnel who speak understandable English and who are experienced in instruction shall conduct training courses.

ii) Bidder shall provide all necessary training material. Each trainee shall receive individual copies of the technical manuals and pertinent documents.

iii) The Owner shall be permitted to video tape all training classes.

iv) Class materials, including documents sent before the training classes and class handouts, shall become the Owner's property. The Owner may copy this material for in- house training and use only.

v) Training sessions shall accommodate the number of candidates as per the contract.

32.61 Cyber security Requirements

It shall be possible to check the integrity/authenticity of the equipment firmware (e.g., using a secure hash or digital signature). Offered equipment should comply to latest cyber security standards of NERC, CIP, CERTIN. Bidder shall submit test certifications from necessary cyber security certification authorities.

The offered systems should be integrated with existing Cybersecurity and network monitoring systems deployed at Tata Power.

The offered equipment should not have any history of compromise due to any cyber-attacks in the past. Bidder shall clearly mention any such past instances & mitigation measures taken to prevent such attack in future.

In addition to warranty clause, bidder shall also be responsible for mitigation of any security threat/compromise happening to the deployed network within the warranty time frame. In event of any cyber security incident appearing bidder will be completely responsible for getting the network back to normalcy within expected time frame as per SLA. Purchaser will not be liable for any additional payments arising on account of getting back network to normalcy with the security incidence appropriately patched.

Any expenses required for hardware or software for such mitigation will be to bidder's account. Security updates and patch upgrades to be considered by bidder for minimum period of 7 years at no additional cost for all communication equipment's offered.

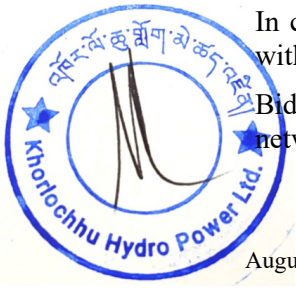
Bidder to offer Antivirus, patch management, scheduled automated backup solution, syslog, Endpoint detection response agents, OT (Operations Technology) sensors, firewall managers and network monitoring solution for all proposed systems offered in generation and transmission. Bidder to consider centralized monitoring platform for Antivirus, patch management, scheduled automated backup, syslog, Endpoint detection response agents, OT sensors, firewall managers and network monitoring solution. Bidder to also consider required servers, software and workstations for monitoring of cybersecurity applications mentioned above centrally.

Cyber security performance and Audit compliance

Bidder to submit Cyber security related test certificates (from accredited Labs) of all offered communication equipment's for technical evaluation.

In case such certificates are not available same to be made available before dispatch with no additional cost to Purchaser.

Bidder should ensure that the installed protection automation and communication network is as per cybersecurity guidelines issued by accredited cybersecurity bodies.



Bidder will perform VAPT/cybersecurity audit through CERT-IN empanelled auditors at FAT and SAT. Reports for the entire protection, automation, plant automation and communication system to be submitted to purchaser during handover. Bidder should ensure all vulnerabilities are patched and observations of the report are mitigated before handover. Bidder should consider periodic audit (frequency as per cyber regulation bodies for Power Industry) of the system deployed for a period of 7 years. During this period any vulnerabilities observed would be bidder's responsibility for necessary patching and mitigation.

32.62 Underground Optical Fiber Cable Conduit

Inner Layer: The inner lubrication material shall be of friction reducing, polymeric material which shall be integral with HDPE layer. The lubricant materials shall have no toxic or dermatic hazards for safe handling. In the finished PLB HDPE duct inner layer shall be integrated part of HDPE and shall be white in colour and clearly visible in cross-section of duct. The density of inner layer material shall be between 0.940 and 0.958 glee at 27°C.

The inner layer of solid permanent lubricant shall be continuous all through and shall not come out during storage, usage and throughout the life of the duct.

The raw material (s) used for the duct shall meet the following requirements:

i) The anti-oxidants used shall be physiologically harmless.

ii) None of the additives shall be used separately or together in quantities as to impair long term physical and chemical properties of the duct.

i) Single pass rework material of the same composition produced from the manufacturer's own production shall be used and it shall not exceed 10% in any case.

ii) The raw material used for extrusion shall be dried to bring the moisture content to less than 0.1 %.

iii) Suitable UV stablisers shall be used for manufacture of the duct to protect against UV degradation, when stored in open for a minimum period of 8 months.

iv) The raw material used in the manufacture of the duct shall be such that the service life of the duct and all its accessories can be expected to be more than 50 years including the life of permanent lubricant.

Source approval: The HDPE resin raw material used in the manufacture of ducts shall have source approval of CACT. The vendor shall clearly mention the manufactures of duct material used for various layers.

The duct shall be supplied with pre-installed rope. The rope shall be polypropylene, 4 mm in diameter and conform to IS: 5175, with a minimum slackness of 2 %.

The Internal Co-efficient of Friction shall not exceed 0.06, when tested with respect to Nylon jacketted un-armoured OF cable, i.e., 96F, 48 F, 24 For 12 F depending on the size of duct.

Identification Markings: The duct shall be prominently marked with indelible ink, with the following information at intervals every metre to enable identification of the pipe. The size of ink markings shall be distinct, clearly and easily visible.

i) Power cable duct

ii) Telephone Emblem

iii) Manufacturer's name

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iv) Name of the duct with size

v) Date of manufacture

vi) Sequential Length marking at every metre along with meter count reading

The manufacturer shall submit third party test certificate like TEC and also submit the test plan for Factory Acceptance Test along with bid.

The acceptance tests shall be carried out on samples selected from the lot for Dimensional and Visual requirements. The requirements for Tensile Strength & Elongation, Reversion Test, Environmental Stress Crack Resistance, Impact Strength, Crush Resistance, Oxidation Induction Test, Hydraulic Characteristics and Internal Co-efficient of Friction shall be part of test plan.

In addition to measuring wall thickness and testing for internal co-efficient of friction at the ends, these two parameters shall be checked at any point between the ends by cutting the duct at intermediate points. The duct thus cut can be supplied to the field with an additional coupler.

The dimensions and breaking load of rope shall be checked when duct is supplied with pre-installed rope.

All the materials shall be stored in the manufacturer's premises in such a manner that it will not affect the performance of the product before dispatch.

Vendor shall give the details about the tools required for installation and maintenance of PLB tubes and also the tools for OFC cable Pulling/Blowing in ducts. Also shall recommend procedure for the same.

Vendor shall supply the 8 push fit couplers / Kilometer along with the supply of duct.

Packing and Delivery: The store shall be supplied in coils of suitable size for delivery in such a manner that they arrive at their destination in a safe and undamaged condition and will permit the loading, unloading and handling in the stores using standard moving equipment. The minimum inner bending diameter of the coiled duct shall be 25 times the outer diameter of duct.

32.63 Miscellaneous

Packaging: The Cables shall be packed in manageable/customised wooden drums with both ends accessible for testing. Both the ends of cable should be duly sealed with end caps and provided with pulling eyes for ease of installation in field. The wooden drum must be circum battened with wooden batons and strengthened with a steel strip over it on both the flanges for protection of the cable during transit

Test Report: Each Drum shall be accompanied with a test report with cable end markings, length, cable no, cable type, fiber count and type and attenuation results of all fibers at 1310nm and 1550nm.

Tools and accessories: Vendor shall specify and quote any specialised tools required for installation and maintenance of supplied cable exclusive of OTDR, Splicer and Optical Power meter.

Specimen Sample: Vendor should provide an appropriate (30 Cm) specimen sample of offered cable/ or of a similar construction type along with quotes.

Instruction Manual: The Vendor shall furnish specified two copies of the instruction manual which would contain detailed step-by-step instructions for all operational, maintenance, testing requirements. The manual shall include, among other information, the following aspects.

i) Storage for prolonged duration

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ii) Unpacking

iii) Erection/Handling at site

iv) Maintenance procedures

v) Manual/Automatic testing procedure

vi) Outline dimension drawings and constructional features

32.64 ABBREVIATIONS

AAL	ATM Adaptation Layer
ADM	Add-drop multiplexed
ATM	Asynchronous Transfer Mode
ALS	Automatic Laser Shutdown
BIP	Bit Interleaved Parity
CAS	Channel Associated Signalling
CAP	Carrier-less Amplitude and Phase
CRC	Cyclic Redundancy Check
DTMF	Dual Tone Multi-Frequency
EFM	Ethernet First Mile
EN	European Norm
EOW	Engineering Order Wire
ERPS	Ethernet Ring Protection Switching
ETS	European Telecommunications Standards
GPS	Global
HDSL	High Density Subscriber Line
IEC	International Electrical Commission
IP/MPLS	Internet Protocol Multi-Protocol Label Switching
ITU	International Telecommunication Union
IP	Internet Protocol
ISDN	Integrated Services Digital Network
MCMI	Multi Coded Mark Inversion
MPLS-TP	Multi-Protocol Label Switching Transport Profile
MS	Multiplex Section
NE	Network Element
NMS	Network Management System
LAN	Local Area Network
OS	Optical Section
OSPF	Open Shortest Path First
PBX	Private Branch Exchange
PDH	Plesiochronous Digital Hierarchy

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PPP	Point-to-Point Protocol
PSN	Packet Switched Network
PTP	Precision Time Protocol
PW	Pseudo Wire
RS	Regenerator Section
SDH	Synchronous Digital Hierarchy
SNMP	Simple Network Management Protocol
SOH	Section Overhead
STM	Synchronous Transport Module
STP	Spanning Tree Protocol
TCP	Transmission Control Protocol
TTI	Trail Trace Identifier
VC	Virtual Container
VF	Voice Frequency
VoIP	Voice over IP
VPLS	Virtual Private LAN Service

32.65 Annexure-1 (Bill of Quantities)

Sl. No.	Description	Qty.SetNos.
1.	Panel mounted Layer3 stacked switches consisting of: 1. Layer 3 switch- 2 No.s, each with: a).24 copper ports 10/100/1000 mbps b) Network expansion module suitable for at least 4 SFP modules 1 Gbps c) Future support for upgradation to 2 uplinks of 10 Gbps d) SFP Transceiver 1310 nm single mode 80 km - 2 Nos. e) SFP Transceiver 1550 nm single mode 120 km - 2 Nos. f) Stacking modules with Stacking Cables g) Power supply module - 48 V DC with cable - 1 No. h) USB compatible console cable i) Accessory kit & Rack mounting kit j) Software license for OS, stacking and other advance routing functions 2.Patch panel 24 ports – 2 Nos. 3 3 Ft UTP CAT6 patch cord - 12 Nos. 4.7 Ft UTP CAT6 patch cord - 6 Nos. 5. I/O Box dual port with RJ45 female connector - 2 Nos. 6. Panel pre wired 42 U – 1 No., 19" 42 U network Panel with all standard accessories (such as Mounting Trays Minimum - 3 Nos. Window Mouldings, Cable Manager-3 Nos., Cable routing trays ,Cooling Fans -4 Nos., Base plate with pre punched knockable inlets for cable entry, Cable Routing trays on both inner walls, Front Glass Door, Split Back door, AC distribution board with minimum 8 outlets) 7. DC MCBs 10A -2 Nos., AC MCB-230V AC - 1 No. 8. Independent Diode Oring Units for each DC Voltage input source, with appropriate current rating 9. MCBs for DC Voltage Input sources, 2 Nos. 48V DC and 2 Nos. 220/110V DC with appropriate current rating 10. Redundant 220/110VDC to 48VDC converter.	3 Nos
2.	Substation Level Firewall in HA with IDS and IPS functionality with 8 Cu ports and associated accessories, cabling, supply and services	3 Nos
3.	SDH & MPLS-TP Hybrid Equipment panel mounted 800*800 42U a. Dual Controller redundant card b. Dual Aggregator redundant Card, 4x 10Gbps SFP/SFP+, 2x 10Gbps Ethernet- Fully loaded SFP with minimum driving distance of 120km c. Tele protection Interface coupler- 3No.s , minimum 4 Command with Tag Block to be mounted on C channel with necessary wiring and tagging details along with alarms to be wired up in SCADA. Interface should have logging and trip log facility with connectivity over FO, C37.94 d. Dual Aggregator redundant Optical protection interface card- 3 No.s, (Supporting IEEE C37.94) 4x SFP,Fully loaded SFP e. Circuit Emulation card supporting G.703, At least 8 x 2Mbps f. SDH Transport card to be integrated with minimum 4 Nos. STM4 or STM1 port,Fully loaded SFP g. Ethernet switching card , 8x 1Gbps ETH port auto negotiable to 100/1000M, with POE supported. h. 800mm*800mm with 42U height Panel swing frame with fans, glass front door, , I/O patch panel for Ethernet, FXO/FXS. Panel should be with	4 Nos

Sl. No.	Description	Qty.SetNos.
	proper termination blocks for each application interface & input power supply along with C channel for mounting of DC & AC MCBs, AC extension unit with 6 universal (5 & 15 A) points, cable manager, front and backside opening with 2 LED tube fitting on push door on/off switch. provision for panel grounding, ventilation, conduit for cable harnessing, internal panel lighting and arrangement for sufficient ventilation. The panel shall have locking arrangement for secure physical access. The cabinet shall have protection from dust, saline, corrosive and highly humid atmospheric and weather conditions. panel should be provided with Cable Ties along with cable trays 3 Nos. for routing of cables.AC power AC power distribution board with 4 power outlets shall be provided. Proper cable entries shall be provided with open & close arrangement for cable entry hole. Universal input 220VDC or 230V AC to output 48VDC Convertor 2No.s with 2 Outputs per convertor and current rating of 13A per convertor - 2 Nos., 48VDC Ungrounded DC to Grounded DC convertor 2 No.s and Diode Oring 2 No.s unit with current rating of 13A per Convertor.	
4.	GPS supporting PTP and NTP with associated accessories, cabling, supply and services	2 Nos
5.	Configuration laptop	2 Nos
6.	Public Address system and associated accessories, cabling, supply and services	3 Nos
7.	VOIP EPABX and associated accessories, cabling, supply and services	3 Nos
8.	Fiber infrastructure Fiber Termination Box Suitable to terminate 12-core Multimode Mode underground Fiber optic cable 19" Rack Mounting with Connectors loaded with MM type pigtails ST type couplers and cassettes. Rodent Proof design.	5 Nos
9.	Fiber infrastructure Fiber Termination Box Suitable to terminate 96-core Single Mode underground Fiber optic cable 19" Rack Mounting with LC type Connectors loaded with SM type pigtails LC type couplers and cassettes. Rodent Proof design.	16 Nos
10	800mm*800mm with 42U height Panel with fans, glass front door, , I/O patch panel for Ethernet, FXO/FXS. Panel should be with proper termination blocks for each application interface & input power supply along with C channel for mounting of DC & AC MCBs, AC extension unit with 6 universal (5 & 15 A) points, cable manager, front and backside opening with 2 LED tube fitting on push door on/off switch. provision for panel grounding, ventilation, conduit for cable harnessing, internal panel lighting and arrangement for sufficient ventilation. The panel shall have locking arrangement for secure physical access. The cabinet shall have protection from dust, saline, corrosive and highly humid atmospheric and weather conditions. panel should be provided with Cable Ties along with cable trays 3 Nos. for routing of cables.AC power AC power distribution board with 4 power outlets shall be provided. Proper cable entries shall be provided with open & close arrangement for cable entry holes	8 Nos
11	Fiber infrastructure12 core Singlemode mode armoured FO-cable	1 Lot
12	Fiber infrastructure12 core Multimode mode armoured FO-cable	1 Lot
13	Fiber infrastructure Fiber Termination Box Suitable to terminate 12-core Single Mode underground Fiber optic cable 19" Rack Mounting with LC type Connectors loaded with SM type pigtails LC type couplers and cassettes. Rodent Proof design.	10 Nos

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Sl. No.	Description	Qty.SetNos.
14	Communication Accessories (Local & associated remote end communication)	3 Lot
15	Leased operator bandwidth from PH units to SLDC, Backup SLDC.	1 Lot
16	Cybersecurity components and monitoring solutions	1 Lot
17	Recommended Spares (10 % to be rounded off to next number)	1 Lot
18	Installation, commissioning, Laying and integration of communication infrastructure with existing system along Supplied modules at local and remote ends	lump sum
19	Fiber infrastructure 96 core Singlemode mode armoured FO-cable with HDPE duct	6000 meters

32.66 Employer's Specifications

Sr. No	Description	Unit	Parameters
	General		
1.1	Type of multiplexer		SDH: ADM
1.2	Complying to ITU-T rec.		Yes
1.3	Transmission Capacity	Gbit/s Mbit/s Mbit/s	STM-16: 2.5 STM-4: 622 STM-1: 155
1.4	Access capacity on 64kbit/s	Channels	>= 200
1.5	Access capacity on 2Mbit/s	Channels	>= 40
1.6	Redundant central processor		Shall be available
1.7	Digital cross connect function		Fully non-blocking
1.8	PDH cross connect capacity		>= 128x2Mbit/s
1.9	SDH cross connect capacity, high order		>= 128x VC-4
1.10	SDH cross connect capacity, low order		>= 1008 x VC-12
1.11	Equipment used in substation environment		List of 5 reference substation projects
1.12	The equipment is KEMA type tested		YES
2	**Teleprotection Interface**		
2.1	Integrated distance tele protection interface		YES
2.2	Integrated IEC 61850 GOOSE based protection interface		YES
2.3	Integrated optical tele protection interface		YES
2.4	Addressing of protection commands		YES
2.5	Loop test for measuring delay time		YES
2.6	1+1 switch-over less than 10ms		YES
3	**Transport Level: Interfaces**		
3.1	Optical STM-16 interface supported		YES
3.2	Optical STM-4 interface supported		YES
3.3	Optical STM-1 interface supported		YES
3.4	SDH based on SFP technology		YES
3.5	Electrical SDH interface		YES
3.6	HDB3, 2Mbit/s interfaces per module		>= 8
3.7	Complying to ITU-T rec.		G.703, transparent G.704, selectable
3.8	Optical 10GE interface supported		YES
3.9	Optical 10GE interface		>= 4
3.10	Optical / Electrical 1GbE interface		>= 100
3.11	Switching capacity of Ethernet Switching Matrix		> 60 Gbit/s full duplex
3.12	MPLS-TP LSP per node		> 800
3.13	OAM frame generation with 3.3 ms speed		> 50
3.14	OAM frame generation with 50 ms speed		> 100
3.15	1+1 bidirectional, symmetrical LSP protection		Yes
3.16	1:1 bidirectional, symmetrical LSP protection		Yes

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Sr. No	Description	Unit	Parameters
3.17	Support of Synchronous Ethernet		Yes
3.18	Support of IEEE1588 v2 transparent clock		Yes
3.19	Support of time of day information using IEEE 1588 v2		Yes
3.20	Accuracy of time of day information per node	µs	< 1 µs
3.21	Number of VLANs supported		> 4000
3.22	MAC address table size		>= 16 k
3.23	Number of ports in link aggregation group		>= 8
4	**SL Interface**		
4.1	DSL type / line code		G. SHDSL
4.2	2Mbit/s: Number of copper wires		4 or 2
	User Interfaces		
5	**Voice Module For Trunk Lines**		
5.1	1+1 path protection, individually programmable		YES
5.2	Analogue, 4wire with E&M: Input level Output level	dBr	+9.5 to –16.0 +7.0 to –16.5
5.3	Analogue, 2wire with E&M: Input level Output level	dBr	+9.5 to – 12.5 –1.0 to – 20.0
5.4	Digital, 2Mbit/s CAS or PRI		YES
5.5	Number of interfaces per module		>= 8
6	**Voice Interfaces For Remote Subscriber**		
6.1	2wire, subscriber side	dBr	-5 … +4 / -7.5 ... -1
6.2	Minimum number of subscribers per module		>= 10
6.3	2wire, PABX side	dBr	-5 … +4 / -7.5 ... -3
6.4	Minimum number of PABX interfaces per module		>= 10
7	**Integrated Teleprotection – Interface For Commands**		
7.1	Number of independent commands per module		>= 4
7.2	Transmission time max.	ms	6
7.3	Protection voltage	Max VDC	250
7.4	1 + 1 path protection		YES
8	**Integrated Teleprotection – Interface For Iec61850 Goose Based Protection**		
8.1	PRP support		YES
8.2	Integration in IEC 61850 substation configuration file		YES
8.3	Capability for wire speed GOOSE signal translation		YES
8.4	Possibility to filter specific GOOSE messages and transmit the same to the remote end		YES
8.5	Trip counters for GOOSE signals		YES
8.6	Authentication of signals to detect data modification in WAN and replay of data		YES
8.7	Back to back latency of IEC 61850 GOOSE based protection interface data channels		≤ 5 ms
8.8	Number of interfaces per module		≥ 4
8.9	IRIG-B outputs		≥ 6
8.10	SNTP client and server functionality		YES
8.11	Status supervision		Telecom NMS and IEC 61850 MMS
9	**Interface(S) For Differential Protection**		

Sr. No	Description	Unit	Parameters
9.1	Optical interface IEC 60870-5-1	kbit/s	Minimum 64
9.2	Optical interface C37.94	Mbit/s	2.048
9.3	Payload for protection relay	kbit/s	64 – 768
9.4	Symmetrical Switching		Yes
10	**Data Module**		
10.1	V.24/V.28 (RS-232)		>= 4 ports / module
10.2	V.11/X.24 (RS-422)		>= 4 ports / module
10.3	V.35		>= 4 ports / module
10.4	Integrated Ethernet port available on DATA Interface		YES
10.5	SW-programmable board available to assign different types of data interface to each port.		YES, as option available
10.6	Functions available for individual configuration: - 1+1 path protection - point-multipoint - performance monitoring available for all data interface		 YES YES YES YES
11	**Ethernet Module**		
11.1	Ethernet A 10/100/1000BaseT 1000Base LX/SX L2 switching function EoS WAN capacity Logical WAN ports GFP (acc. ITU-T G.7041) VCAT (acc. ITU-T G.707) LCAS (acc. ITU-T G.7042) xSTP	 Mbit/s	 >= 100 >= 100 YES >= 2 Gbit/s >= 32 YES YES YES YES
11.2	Ethernet B 10/100BaseT L3 Routing function Routing protocols WAN capacity WAN ports WAN protocol		 YES YES static IP routing OSPF2 V2 >= 8x 2Mbit/s (64kbit/s granularity) >= 30 PPP, HDLC
11.3	Ethernet C FE/GbE optical/electrical i/f Virtual routing (VRF/VPRN) Wire speed forwarding OSPFv2 (RFC 2328) OSPF auth. (Simple/ MD5) VRRPv3 (RFC 5798)basic FW (ACL rules/ DoS prot.) port and VLAN based rate limiting L3 HW supported QoS (DSCP) 1:1 HW protection (EQP) VLAN interfaces per module VRRP instances per module		>10 per module YES YES YES YES YES YES YES YES YES >128 >128 >32

Sr. No	Description	Unit	Parameters
	VRRP link tracking per module 1:1 NAT support		YES
11.4	Ethernet D Power over Ethernet	ports	>= 6
12	**Integrated Alarm Gathering Module**		
12.1	Number of external alarms per module		>= 8
12.2	Auxiliary power supply for ext. contacts		YES
13	**Configuration Tool**		
13.1	Type/Name of configuration tool		
13.2	For local / remote operation		YES / YES
13.3	Data communication network (DCN)		Ethernet / IP
13.4	Integrated Management of Tele protection Command module		YES
14	**Network Management System**		
14.1	Type/Name of configuration tool		
14.2	For fault / configuration management		YES / YES
14.3	Data communication network (DCN)		Ethernet / IP
14.4	Management of integrated Tele protection Command Module		YES
15	**Ambient Conditions**		
15.1	Storage: ETS 300 019-1-1, class 1.2	°C/ % hum	- 25 … + 70°C / 95%
15.2	Transport: ETS 300 019-1-2, class 2.2	°C/ % hum	- 25 ... + 70°C / 95%
15.3	Operation: ETS 300 019-1-3, class 3.1E	°C/ % hum	- 20 … +60°C / 95%
15.4	Operation in fan less configuration	°C/ % hum	- 20 ... +55°C / 95%
16	**Power Supply**		
16.1	Operation	VDC	48 / 60 (-15/+20%)
16.2	Dual power feeding		YES

32.67 Employers Specification of FOC

Fiber Specifications:96 fibers underground armored cable

Fibers shall comply with the latest revision of ITU-T G652D (10/2000)

Sr. No.	Specification	Unit	Value
A	**Dimensional Specification**		
1	Mode field diameter at 1310 nm	µm	9.1 ± 0.4
2	Mode field diameter at 1550 nm	µm	10.2 ± 1.0
3	Mode field diameter non circularity	% ≤	6
4	Cladding diameter	µm	125 ± 1.0
5	Cladding non circularity	% ≤	1
6	Core / cladding concentricity error	µm ≤	0.6
7	Coating diameter (coloured)	µm	242 ± 7
8	Cladding / coating concentricity error	µm ≤	12
B	**Optical Specifications**		
9	Attenuation at 1310 nm	‘dB/km ≤	0.36
10	Attenuation at 1550 nm	‘dB/km ≤	0.22
11	Chromatic dispersion at 1550 nm	‘ps/(nm-km) ≤	18
12	Chromatic dispersion between 1285 nm and 1330 nm	ps/(nm-km) ≤	3.5
13	Cut-off wavelength (cable fibre) λcc	‘nm ≤	1260
14	Zero-dispersion wave length	‘nm	1310 ± 10
15	Zero-dispersion slope	‘ps/(nm2-km) ≤	0.09
16	PMD (Quadrature Average)	‘ps/√km ≤	0.1
C	**Mechanical Specification**		
17	Proof Test stress > 100 kpsi (0.7 GN/m2)n Strain equivalent	%	1
18	Coating strip ability (50mm, 500 mm/min)	N	1 … 5
19	Bending test, additional loss at 1550 nm, 100 turns on 60 mm mandrel	dB/km ≤	0.05
20	Bending test, additional loss at 1550 nm & 1625 nm, 1 turns on 32 mm mandrel	dB/km ≤	0.5

Note1: The preferred fiber should be of Corning or Sumitomo make.

Note2: Fibre manufacturers test report should be submitted.

COLOUR DETAILS	
Optical Fibre Colour	Blue, Orange, Green, Brown, Slate, White, Red, Black,Yellow, violet, pink and aqua
Loose Tube Colour	Blue, Orange, Green, Brown, Slate, White, Red and Black.
Sheath Colour	Orange



32.68 Employer's Specification of HPDE Pipe

Permanently Lubricated HDPE pipe for use as Underground Optical Fiber Cable Conduit

Specification for PLB Duct:

Sr. No	Parameters	Ref. TeSst Method	Unit	Typical Value / Requirement
Dimensions & Tolerances:				
1	Nominal Outside Diameter	GR. No.G/CDS-08/02.Nov 04	mm	40 + 0.4
2	Wall Thickness	GR. No.G/CDS-08/02.Nov 04	mm	3.5 ± 0.2
3	Thickness of inside lubrication	GR. No.G/CDS-08/02.Nov 04	mm	10% of Pipe Thickness
4	Lubrication	GR. No.G/CDS-08/02.Nov 04	mm	Permanently lubricated for blowing of Optical Fiber Cable
5	Ovality	GR. No.G/CDS-08/02.Nov 04	mm	1
6	Length	GR. No.G/CDS-08/02.Nov 04	mm	500 ± 10 or as per requirement
DPE Raw Material				
	Density	IS : 2530 : 1963	G/CC	0.940 to 0.958 at 27° C
	Melt Flow Rate	IS : 7328 : 1992	Gm/10 min.	0.2 to 1.10 at 190° C under 5 Kg Load
	The raw material shall contain required additives. such as antioxidants, UV stabilisers etc. in the raw material itself.			
Visual appearance:				
1.	Surface Finish	GR. No.G/CDS-08/02.Nov 04		Duct is smooth, clean, round and free from blister, shrink, holes, flaking & other defects
Performance Requirement :				
	Heat Reversion	IS : 4984 : 1995	%	Max 3%
	Hydrostatic Pressure Resistance Test	IS : 4984 : 1995		Acceptance Test:
				Duration: 48 hrs at 80°
				Induced Stress 3.8 Mpa
				Type Test :
				Duration: 165 hrs at 80° Induced Stress: 3.5
	Tensile Strength & Elongation	IS : 14151 (part-1)	N/mm2	Min. 20 N/mm2
			%	600%

	ESCR	ASTMD 1693		No Failure
	Impact	IS:12235 (part-9)		Striker Weight 10 kg, Duct Shall not crack or split
	Crush Resistance	GR. No.G/CDS-08/02.Nov 04	%	Approx. 50 kg Load with load deflection <10 after> recovery<2
	Oxidation Induction Test	GR. No.G/CDS-08/02.Nov 04	Min	Time > 30
	Internal Co-efficient of Friction	GR. No.G/CDS-08/02.Nov 04		COF < 0.06
	Minimum bending radius during storage	GR. No.G/CDS-08/02.Nov 04	Mtrs.	1.25
	Maximum pulling force	GR. No.G/CDS-08/02.Nov 04	Kg	320
	Ash Content of Finished Duct	GR. No.G/CDS-08/02.Nov 04		0.3 (Max)
	Fading of colors of Duct	GR. No.G/CDS-08/02.Nov 04		No Discoloration
	UV Stabilizer Content of Resin	FT-IR Method	%	0.15 (Minimum)
	UV stabilizer Content of Duct	GR. No.G/CDS-08/02.Nov 04		Variation in tensile strength after aging is not more than 20%
	Marking Identification	GR. No.G/CDS-08/02.Nov 04		All pipes are marked in white color by hot embossed as per detail specified by the client, with length mark at every meter. 4 white strips applied on duct in the longitudinal direction. Color: Orange.
	Flexural Modulus at 1% strain	GR. No.G/CDS-08/02.Nov 04	N/mm 2	690 N/mm2 minimum,
	Hardness, Shore-D	GR. No.G/CDS-08/02.Nov 04		Between 60 and 65 units
	Heat Temperature at Deflection 45 g/mm	GR. No.G/CDS-08/02.Nov 04	Degree Celsius	65 degree celcius
	Environmental Stress Crack resistance, When tested with 10% Igepal, co 0630 Solution at 50° C	GR. No.G/CDS-08/02.Nov 04		96 hrs., when tested as per ASTM D 1693, No cracks
	Weathering in artificial (UV) light. (Specimens shall be as per ASTM D 638Type-IV) and cut from compression moulded. sheet	GR. No.G/CDS-08/02.Nov 04		After exposure for 720 hrs Tensile strength shall be tested. variation shall not be. greater than 20% compared. to tensile strength obtained at c) above.

Duct Accessories				
1	Coupler (Push Fit) Internal air pressure:	GR.No.G/CDS 08/02. Nov.2004	kg./cm2	Internal air pressure 15kg./ cm 2
2	Pulling force:	GR.No.G/CDS 08/02. Nov.2004	Kgs.	Pulling force: For 40mm: 320 Kgs.
3	Ageing Test: In air circulating oven	GR.No.G/CDS 08/02. Nov.2004		Ageing Test: In air circulating oven at 70 ± 2°C for 168 hrs.
4	Cable sealing plug	GR.No.G/CDS-08/02.Nov.2004	1kg/cm2	1 kg / cm2 Air pressure for 30 minutes.
5	End Plug	GR.No.G/CDS-08/02. Nov.2004	kg/cm2	1 kg/cm2 Air pressure for 30 minutes.

32.69 Applicable Standards

Sl , No.	Title	Reference Standard
1	Telecontrol equipment systems Optic fibre cables	ASTM E 29, IEC 60870,IEC 60793-1(1984), IEC 60794 (Part - 3), ITU-T REC. G652 & REC.G651,B.S 6558 PI
2	Radiated radio frequency interference	EN 55022
3	Conducted radio frequency interference AC/DC Power supply	EN 55022
4	ESD test	IEC 61000-4-2
5	Radiated electromagnetic field	IEC 61000-4-3
6	Radiated electromagnetic field	IEC 61000-4-3
7	Fast transient test	IEC 61000-4-4
8	Surge test (1.2/50 µs)	IEC 61000-4-5
9	Conducted radio frequency interference	IEC 61000-4-6
10	Power frequency magnetic field	IEC 61000-4-8
11	Damped oscillatory waves	IEC 61000-4-12
12	Conducted common mode disturbance	IEC 61000-4-16
13	Standard Test Procedure for fiber optic fiber, cables, Transducers, Sensors, Connecting and Terminating devices, and Other Fiber Optic Components	EIA / TIA – 455-A
14	Procedure to Measure Temperature Cycling Effects on Optical Fiber, Optical cable, and Other Passive Fiber Optic Components	EIA / TIA – 455-3A
15	CABLE IMPACT TEST 5KG MASS ,10 impacts from 550mm height with 12.5 mm radius of curvature of transfer tool.	IEC-794-1-E4
16	CABLE TENSILE STRENGTH TEST The tensile rating for the cable is :1.3x Wx9.81n for fiber strain <=0.25% for 10min duration .Here W=Cable WTIN KGS/KM.	IEC-794-1-E1
17	CABEL BEND TEST 4 Wraps &unwraps on mandrel diameter of 20xD, 10 cycles.	IEC-794-1-E11
18	CABLE COMPRESSION TEST 4000 N Compressive load 100mm square compressive plates ,10 min duration	IEC-794-1-E3
19	CABLE TORSION TEST 10cycles of 360deg clockwise twist ,360 deg counter clockwise twist ,L=2m with load of 400N.	IEC-794-1-E7
20	CABLE REPEATED BENDING 90 deg angle turn with pulley diameter of 20xD,where d is cable diameter ,@30 cycles/2 minutes, repeatedly on both sides.	EIA-455-104
21	CABLE KINK TEST Length, ten times of min. Bend radius loop stretched in opposite direction till min bend radius of loop.	IEC-794-1-E10
22	CABLE TEMPERATURE CYCLING TEST 1 cycle of exposure for 12 Hours each at -10°C,-20°C,+60 °C and +70 °C.	IEC-794-1-F1

32.70 Mandatory Spares

Sl. No.	Item	Quantity
1	**FIBRE OPTIC COMMUNICATION SYSTEM**	
1.1	SDH Equipment, Common cards, Cross Connect/control cards, optical base cards, power supply cards	1 set
1.2	Optical Interface Cards	1 set
1.3	Interface cards & accessories	1 set
1.4	Ethernet Interface 10/100 Base T with Layer-2 switching (Min 8 Interfaces per card)	1 set
1.5	Gigabit Ethernet (Layer 2) Interface (min. 1 nos.)	1 set
1.6	VOIP telephone with 01 common switch (min 8 port)	1 set
1.7	Patch cord	6 Nos each Type

CHAPTER 33: 132kV FEEDER BAY AT KORLUNG SUBSTATION

33.1 Scope of Work

This specification covers the design, detailed engineering, construction/manufacture/supply, inspection & testing at Vendor's and/or his Sub-Vendor's works, packing, transportation, loading and unloading, delivery at site, storage at site, handling at site, erection, start-up & Commissioning and performance testing of all equipment/systems of 132 FEEDER BAY Panel & switchyard at generating end and accessories including civil works as specified hereafter.

A 132/33kV switchyard shall be provided for evacuation of power generated at the plant as well as get start up power. The BIDDER shall develop all the drawings as per actual requirement and submit them for Purchaser's approval. The switchyard scheme SLD enclosed for reference.

The 33kV switchyard / switchgear at generating station end shall consist of following bays:

Sl. No.	Description	No. of Circuits
1	132kV Incoming Bay at Korlung Substation (Isolators/CTs/LA/CB/ ect for ICT connection)	1 Set
2	36kV Two pole Structure (1Set), 33kV LA (3 nos) and Isolator , Two Earth Switch(1Set) with all accessories for DAM area	1 Set
3	Tariff metering system for Khorlochhu HPP-Incomer	1 Set

Switchyard/panel shall be designed considering the space provision future expansion of additional one line bay.

The switchyards shall be supplied and installed with all equipment/systems and accessories to make the switchyards complete in all respects. The switchyard shall include all the equipment/systems indicated below but not limited to the following.

i) Double pole structure with all supporting insulators, isolator with earth switch, handle & locks, Lightning arrestor, stay wire, jumpers, bimetallic clamps and as required,

ii) CT PT unit for protection , metering and Tariff metering.

iii) Isolator with Earth Switch.

iv) Circuit Breaker.

v) Surge Arrester.

vi) ACSR conductors, clamps and connectors

vii) Required earthing & Lightning.

SCADA (Supervisory Control and Data Acquisition) system for control and monitoring of entire plant including switchyard. The control location for the switchyard control shall be main plant control room through SCADA. However, necessary meters, transducers and sensors to be provided by BIDDER. Close and trip commands to switchyard equipments shall be through IPRs located on Control & Relay (C&R) Panels. Location of Panel shall be in main plant control room. The communication between the numerical relays and SCADA shall be through IEC-61850/MODBUS protocol.

Protection panels for all bays / equipment, communication and interfacing panels as required including disturbance recorder with suitable time synchronizing facility.

Tariff metering along with CTPT units

Earthing and direct stroke lightning protection system for proposed generating end switchyard in BIDDER's scope.

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All switchyard / switchgear panel (at generating end) equipment signals shall be wired (including all power, control & instrumentation cables, cable carrier system, etc) up to C&R panel. Cabling from C&R Panel to SCADA shall also be in BIDDER's scope.

It is the scope of the BIDDER to closely co-ordinate with the grid authorities for all the specification requirements and interfaces pertaining to protection, metering, communication and data transfer to Load despatch centres, PLCC requirements, cabling and any other requirements.

Determination of all relay settings and obtaining approval of relay settings, co-ordinating with remote end protection and communication systems, etc. with the respective grid authorities is deemed to be included in the BIDDER's scope.

It is not the intent to completely specify herein all details of design and construction of the equipment/systems. However, all equipment/systems shall conform in all respects to high standards of engineering, design and workmanship and shall be capable of performing continuous operation up to the BIDDER's guarantees in a manner acceptable to the PURCHASER who will interpret the meaning of drawings and specifications and shall have the power to reject any work or material which in his judgement are not in full accordance with the requirements. All the major equipment shall be installed tested and commissioned under supervision of representative of original manufacturer of respective equipment.

Although most of the systems are covered here, any other equipment/system required for successful completion of the works shall form part of this contract and shall be deemed to be included in the BIDDER's scope of works.

All equipment shall be suitable for smooth, efficient and trouble free operation for the site conditions and power supply variations as mentioned in General Project Information. All switchyard equipment shall comply with the specification requirement indicated in this section and associated Data Sheets.

33.2 Codes and Standard

The equipment design, manufacture, supply & storage, erection, testing and commissioning of 33kV switchyard shall comply with the latest edition of codes and standards specified in this specification.

Equipment complying with other internationally accepted standards shall also be considered if they ensure performance and constructional features equivalent or superior to standards specified.

33.3 Design Criteria

The switchyard shall be suitable for outdoor application having saline atmosphere and shall have tropical and fungicidal treatment.

All structural steel and steel components in the switchyard equipment shall be hot dip galvanized.

The 132 kV switchyard shall be designed for a short circuit current of 40 kA for 1 seconds. And The 33 kV switchyard shall be designed for a short circuit current of 31.5 kA for 1 seconds.

The conductor size of tubular bus / stranded conductors shall also be sized considering short circuit conditions, corona / voltage gradient and effect of solar radiation.

The final temperature of the conductor when carrying full load current shall not exceed 75°C considering maximum design ambient temperature.

Complete switchyard shall be designed to withstand seismic acceleration as per relevant IS.

The minimum clearances to be followed for the 132kV and 33 kV switchyard shall be as mentioned in datasheet-A.

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The switchyard shall be provided with access ways and adequate space for maintenance of equipment.

33.4 Switchyard Layout Requirements

The BIDDER shall note that the sequence of bays shall be so arranged that the maximum horizontal angle of deviation of the incoming power and shielding conductors from Generator Transformer do not exceed 30º to the center line of the bay. Similarly, the point of anchoring on TG building shall be such that the vertical angle of deviation is limited to 30º from horizontal plane. It will be decided during detailed engineering.

The BIDDER shall adopt bolted type connectors for ACSR bus conductors, fixed type of terminal connectors for isolator terminals, flexible type of terminal connectors for circuit breakers, current transformers and reactors and flexible jumper connectors for connecting lightning arresters and voltage transformers. Every bus shall have a flexible at one end of the bus and at suitable intervals of the bus to allow thermal expansion.

The BIDDER shall consider suitable bay width, phase spacing, clearances, etc., depending on the actual dimensions of the equipment keeping in view the design criteria / requirements and without sacrificing any maintenance space / conveniences.

ACSR bundled stranded conductor shall be used for the connection between the generator transformer gantries and incoming gantries in the switchyard and the Power house building. The ACSR conductor shall be properly sized for normal current capacity and short circuit rating.

The switchyard shall be provided with access ways near the current transformers and circuit breakers and isolators/earth switches.

The cable trenches for the equipment shall be run as close to their foundations as possible even preferably touching. All the cable trenches shall be covered with RCC slab.

The switchyard shall be enclosed in fence around for safety and to prohibit unauthorised persons from entering. Lockable gates for personnel entry and equipment shall be provided at convenient locations. The fence provided around switchyard shall be of 3000mm height and at a minimum distance such that section clearance is available from any live part. The fence shall be suitably earthed as per relevant standards.

The switchyard equipment shall be suitable for outdoor installation and shall have tropical and fungicidal treatment.

The soak pit and burnt oil pit for the transformers shall be sized as per norms indicated in CBIP Manual for Fire Protection of Power Transformers.

Earth mat of suitable size with closely spaced earth conductor shall be provided below the operating handle of individual switchyard equipment.

Design criteria for civil works and structures shall be as per the details mentioned in Civil section of this specification, as applicable.

33.5 Constructional Features

The double pole structure shall be of minimum 200x100mm RSJ structure with all supporting insulators, Isolator with handle & locks, Lightning arrestor, stay wire, required jumpers, bimetalic clamps.

33.5.1 Isolators:

The isolator shall be horizontal double break type.

Isolators shall be suitable to operate manually. The earth switches shall be manually operated with proper interlock so that it shall not operate in case respective isolator is ON and other requisite conditions are not met.

Base channels and other structural steel members such as operating pipes, phase coupling rods, operating mechanism boxes, bolts, pins, etc. shall be hot dip galvanised. All castings except current carrying parts shall be made of malleable cast iron or cast steel. Manual operating handles shall be galvanised steel.

The isolator or earthing switch shall be provided with high current carrying contacts on the hinge and jaw ends and all contact surfaces shall be of silver faced copper.

A mechanical position indicating device shall be provided for each disconnector / earthing switch.

The design of the auxiliary switches for the isolators shall be such that signalling of the closed position shall not take place unless the contact system has reached such a position that the rated current and the rated short time current can be carried safely and signalling of the open position shall not take place unless the contact system has reached a position of at least 80 percent of the clearance distance of the isolating distance.

Adequate NO/NC contacts shall be provided for isolator & earth switch for remote indication & interlocks.

33.5.2 Lightning Arrestor

30kV, 10kA nominal discharge current, class-3, pressure relief class-A, metal oxide, gap less lightning arrester for 33kV switchyard shall be provided.

Arrester shall be suitable for installation in effectively earthed system.

Grading resistors and/or grading capacitors and grading rings shall be provided for uniform voltage distribution between the units making up the arrester, as dictated by the voltage class of the arrester.

The arrester shall be mounted on an insulating base.

All metal parts shall be of non-rusting and non-corroding metal. Bolts, screws and pins shall be provided with lock washers, keys or equivalent locking facilities.

Insulators / bushings shall conform to applicable standards and shall be made of homogeneous vitreous porcelain, the glazing of which shall be of uniform brown or dark brown colour.

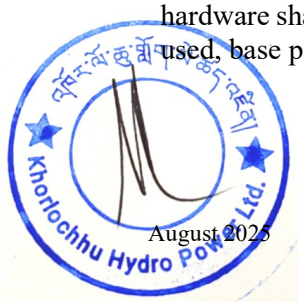
The porcelain shall be sound, free from defects, thoroughly vitrified and smoothly glazed. Insulators shall have compression type glaze with a good lustre and of uniform brown colour. The glaze shall be unaffected by sudden changes in temperature and by atmospheric pollution of ozone, acids, alkali, dust etc.

Insulators shall be designed to avoid excessive concentration of electrical stresses in any section or across leakage surfaces.

Except where otherwise specified nonmagnetic bolts shall be used. Bolts shall be of sufficient strength to withstand without bending, the stresses introduced in them, when they are stressed to their rated strength. The bolts shall be readily removable after the fittings have been so stressed. Locking and split pins shall be of hard drawn brass, bronze or stainless steel. All castings shall be free from blow holes, cracks and other casting defects.

All current carrying parts shall be designed and manufactured to have minimum contact resistance.

Fittings intended to connect two dissimilar metals, shall be designed to avoid harmful bimetallic corrosion under service conditions. Minimum breaking strength of insulator hardware shall not be less than that of insulator connecting string. Where parallel insulators are used, base plates at the top and bottom shall be of sufficient strength.



33.5.3 Capacitive Voltage Transformer

The instrument transformers i.e., Current and Voltage transformers shall be single phase transformer units and shall be supplied with a common marshalling box for a set of three single phase units.

CVTs shall be oil filled hermetically sealed type

In case of SF6 filled CTs/EMVTs, it shall be provided with a suitable SF6 gas density monitoring device, with NO/NC contacts to facilitate remote annunciation and tripping in case of SF6 leakage. Provisions shall be made for online gas filling. Suitable rupture disc shall be provided to prevent explosion.

The CTs, CVTs and EMVTs shall be given tropicalised treatment for satisfactory operation in hot and humid climate.

The Capacitive voltage transformers (CVT) shall be thermally and dielectrically safe when the secondary terminals are loaded with guaranteed thermal burdens.

The damping device shall be permanently connected to one of the secondary winding and shall be capable of suppressing ferro-resonance oscillations.

CVTs shall be suitable for high frequency (HF) coupling for power line carrier communication. Carrier signals must be prevented from flowing in to potential transformer (EMU) metering circuit by means of RF choke/reactor suitable for effective blocking of the carrier signals over the entire frequency range of 40kHz to 500kHz. HF terminal shall be brought out through a suitable bushing and shall be easily accessible for connection to the coupling filters of the carrier communication equipment. The HF terminal shall be provided with earthing link with fastener.

Capacitance value of CVT shall be suitable for PLCC frequency range and it shall be subjected to approval by respective approving authorities.

The end of the primary winding intended to be earthed shall be brought out through a bushing and earthing connection shall be made outside by means of disconnecting link. This is required to facilitate meggering of the primary winding for which the earth connection has to be removed. The neutral side bushings of the voltage transformers shall be rated for 1.1kV class.

A protective surge arrester/spark gap shall preferably be provided to prevent breakdown of insulation by incoming surges and to limit abnormal rise of terminal voltage of shunt capacitor, tuning reactor, RF choke, etc. due to short circuit in transformer secondary. The details of this arrangement (or alternative arrangement) shall be furnished by Bidder for Owner's review.

The protection cores shall not saturate at about 1.5 times the rated voltage for a min. duration of 30 secs.

The CVT secondary shall include necessary MCBs with auxiliary contacts for alarm for protecting the secondary winding. All the terminal boxes shall be hot dip galvanized with IP-55 degree of protection.

CVT assembly shall be suitably braced to withstand stresses induced due to seismic disturbances. The tank/base and all exposed ferrous parts shall be hot dip galvanized conforming to applicable standards

No turns compensation will be used in case of class 'PS' CTs. Turns compensation, if any, should be clearly brought out in the offer.

Oil filled insulator / bushings shall be hermetically sealed to prevent ingress of moisture. A cushion of nitrogen gas may be provided to allow for expansion. Care should be taken in design to ensure no nitrogen leakage.

Neutral of all cores of CTs, CVTs and EMVTs shall be formed in marshalling box of the respective equipment. Cables with sufficient number of cores shall run from these marshalling

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boxes to protection panels. The neutral of CTs, CVTs, and EMVTs shall be earthed only at protection panels by means of a disconnecting link.

For CTs, EMVTs and CVTs, shock indicators shall be provided for recording shock/vibration during transport.

The CTs, EMVTs & CVTs shall be suitable for hot line washing.

Name plate shall conform to the requirements of IEC/IS incorporating the year of manufacture. The rated current, extended current rating in case of current transformers and rated voltage, voltage factor in case of voltage Transformers shall be clearly indicated on the name plate. The rated thermal current in case of CT shall also be marked on the name plate.

The intermediate voltage in case of capacitor voltage transformer shall be indicated on the name plate.

The instrument transformers shall be provided with the following accessories:

i) Two earthing terminals on tanks on opposite sides for connecting the earthing conductors.

ii) Oil level gauge/Oil sight glass

iii) Filling and draining plugs

iv) Power factor testing terminal

v) Facility for lifting bushings and tanks

vi) Insulating oil required for first filing plus 10% as spare. Dielectric Dissipation Factor (tan d) of the transformer oil shall be < 0.005.

vii) The number of secondary cores, accuracy class and burden shall be in accordance with the requirements of the protection and metering system.

viii) The rated burden of Voltage Transformer cores shall be closer to the maximum burden requirement of metering and protection system for better sensitivity and accuracy and it shall not exceed 30VA.

ix) The accuracy class for metering core shall be equal to or better than the accuracy class of the meter specified in the Central Electricity Authority (Installation and Operation of Meters) Regulations, 2006.

x) Wherever Power Line Carrier Communication is provided, Capacitor Voltage Transformer complying with relevant standards shall be used as the same are suitable for carrier coupling and the capacitance of Capacitor Voltage Transformer shall be decided depending on Power Line Carrier Communication requirements.

xi) In case of digital substations, Non-Conventional Voltage Transformers or conventional Voltage Transformers with merging units that are interfaced with the process bus and station bus architecture shall be used.

33.5.4 Current Transformers

The CTs shall have single primary of either ring type or hairpin type or bar type. In case of low ratio CTs, multi-turn primary windings may be used.

The secondary windings shall be totally encased in metallic shielding providing a uniform equipotential surface for even electric field distribution.

The upper part of insulation assembly sealing on primary bar shall be properly secured to avoid any damage during transportation due to relative movement between insulation assembly and top dome.

The lowest part of the insulation assembly shall be properly secured to avoid any risk of damage due to transportation stresses.

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For 0.2S class CT, accuracy shall be maintained between 1% to 120% of rated current.

CTs shall be suitable for high speed auto re-closing (wherever required).

The core lamination shall be of cold rolled grain-oriented silicon steel or other equivalent alloys. µmetal or nano- crystalline core may also be used for metering core to meet the required accuracy. The cores shall produce undistorted secondary current under transient conditions at all ratios with specified parameters.

Polarity marks shall indelibly be marked on each instrument transformer and at the lead terminals at the associated terminal block.

The CTs shall be suitable for horizontal transportation. The CTs shall have provision for taking oil samples from bottom of CT without exposure to atmosphere to carry out dissolved gas analysis periodically. Bidder shall give his recommendations for such analysis, i.e. frequency of test, norms of acceptance, quantity of oil to be withdrawn and treatment/corrective actions for CT.

Power Factor terminals to measure tan-delta and capacitance shall also be provided.

The rated currents and ratio, the number of secondary cores, accuracy class, burden, secondary winding resistance, knee point voltage, and excitation current shall be in accordance with the requirements of the protection and metering system.

The rated burden of cores shall be closer to the maximum burden requirement of metering and protection system for better sensitivity and accuracy and shall not exceed 30 VA.

Instrument Security Factor shall be less than five for Current Transformers upto 400 kV voltage class and less than ten for Current Transformers of 765 kV and 1150 kV voltage class.

The accuracy class for metering core shall be equal to or better than the accuracy class of the meter specified in the Central Electricity Authority (Installation and Operation of Meters) Regulations, 2006.

In case of digital substations, Non-Conventional Current Transformers or conventional Current Transformers with merging units that are interfaced with the process bus and station bus architecture shall be used.

33.5.5 Terminal / Marshalling Box

Secondary terminals of CTs shall be brought out in a weatherproof powder coated terminal box. Facility shall be provided for star delta formation, short circuiting and grounding the CT secondary at the marshalling box. All the taps of each core shall be wired to Marshalling Box to facilitate ratio changing. The box shall have a degree of protection IP-55. Tariff metering core terminals (for connecting main and check meters) shall be housed in separate sealable terminal box.

33.5.6 Insulators/Bushings

Anti fog polymeric bushing insulators shall be used for housing various equipment. Polymeric Insulators / bushings shall conform to applicable Standards.

The bushing/ insulator shall be one piece without any metallic flange joint.

33.6 Tests

The Instrument transformers (CTs, CVTs, EMVTs) shall be subjected to routine test as per IEC in the presence of Purchaser's representative.

Certified copies of reports of type tests carried out on similar type and rating within last five years from the date of submission of Bid shall be furnished to the Purchaser for review and approval.

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In case the type test reports are not found to be meeting the specification requirements, the BIDDER shall conduct all such tests under this contract free of cost to the Purchaser and submit the reports for approval.

All Type test certificates should be from Govt. test houses or NABL approved/Govt. approved laboratories unless the same have been carried out by Contractor/Manufacturer at manufacturers premises in presence of 3rd party.

33.7 Clamps and Connectors

The clamps and conductors shall be made of materials listed below. Clamps and connectors shall be wedge type only.

For connecting ACSR conductors	Aluminum alloy coating
For connecting equipment terminals made of copper or brass to ACSR conductors	Bimetallic connectors of aluminum alloy casting, with copper alloy liner.
For connecting GI shield wire	Malleable iron casting
Bolts, nuts, plain washers and spring washers for above	Hot dip galvanized mild steel of ultimate strength
For copper to copper, copper to brass or : brass to brass conductors	Copper alloy
Bolts and nuts for above	Rolled brass rods
Spring washers for above	Phosphor bronze

All castings shall be free from blow holes, surface blisters, cracks and cavities.

Outdoor mounted, powder coated marshalling boxes shall be provided in the switchyard as required.

220V DC power supply shall be provided for control, protection, interlock and annunciation requirements of the 132/33kV switchyard.

Required no. of 415V/240V DB / feeders shall be provided for catering to all the loads (such as breaker / isolator operating mechanisms, bay marshalling boxes, lighting, etc.) pertaining to the switchyard.

33.8 Tariff Metering

Tariff meters shall comply with CEA, Electricity supply code & MPERC regulations.

Meters & metering equipment shall be tested as per provision of MPERC and as per IS 14697 at CPRI or at any NABL accredited lab.

The tariff meter shall be ABT meter with latest models.

The ABT meter shall be of 0.2s accuracy class and of open protocol confirming to IS:15959 with AMR facility. For providing AMR facility, RE generators shall have to install modem and SIM (capable of working on both GPRS & GSM network) enabled at the interface point and integrating the meters with the AMR system of Secure make installed at SLDC, for data transfer between energy meter and AMR system at SLDC over the GSM/GPRS communications network (as per the procedure laid down in SLDC website).

The tariff metering shall be calibrated and tested in the presence of Owner's representative.

Main & Check meter shall be provided.

Meters for export / import shall be considered separately, if it is not accepted by local Electricity board for measuring / recording both import & export reading in one meter.

Metering instrument transformers of accuracy Class 0.2s shall be supplied for revenue metering to record the import and export of power.

Provision for SCADA connectivity shall be considered.

Necessary transducers shall be provided.

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Panel dimension, color, etc shall match with substation requirement.

Panel shall be free standing, floor mounted, sheet steel enclosed, dust, weather and vermin proof providing a degree of protection of IP 52 for indoor use and IP 55 for outdoor use. Sheet Steel used shall be cold rolled and at least 2.0mm thick and properly braced to prevent wobbling. Panel shall be supplied completely wired, ready for the external connections. Necessary sealing/locking arrangement as per MPSEB requirement shall be provided.

For tariff metering the voltage drop shall be limited to 0.2%. In case the voltage drop with 2.5 sq. mm conductor exceeds this value, higher conductor sizes shall be used

33.9 Earthing & Lightning Protection

Earthing & Lightning protection system shall be provided for switchyard area.

Earthing system shall consist of earth grids, earth pits, and electrodes buried in soil in the switchyard area, embedded in concrete inside the buildings to which all the electrical equipment, metallic structures are connected to have earth continuity for safety reasons. The earth pits shall be provided with disconnecting facility for monitoring of earth resistance.

Earthing system will be designed considering suitable corrosion allowance based on earthing conductor material and type of soil, for a service life of at least fifty (50) years for fault current 40 kA for 1 second. The minimum rate of corrosion of earthing conductor shall be considered as 0.12mm per year while determining the conductor size.

Minimum spacing between electrodes shall be 600mm. Earth pits shall be treated with salt and charcoal if average resistance of soil is more than 20ohm meter.

Earthing conductor shall be buried at least 2000mm outside the fence of electrical installations. Every alternate post of the fences and all gates shall be connected to earthing grid by one lead.

The soil resistivity data will have to be determined by the BIDDER. BIDDER shall design the earthing system based on the actual soil resistivity data. The earthing system design and installation shall generally comply with IEEE-80, IE Rules and IS-3043.

Power house earthing system shall be interconnected to Switchyard earthing system to with minimum 2 Nos of earth conductors.

The size of conductors for lightning protection system shall be decided based on mechanical strength and as per IS/IEC 62305.

33.10 Essential / Mandatory And Recommended Spares

Spare parts required for start-up, site testing & commissioning of the offered equipment shall be included in the scope of work & provided as required. List of recommended spares for Five (5) years of operation shall be furnished along with the bid.

Mandatory spares shall be included in the Bid. Also, the BIDDER shall provide free upgrades for software for a period of Five (5) years from the date of commissioning of last unit.

33.11 Testing and Inspection

TESTS AT MANUFACTURER'S WORKS

Routine tests for Switchyard equipment shall be carried out on completely assembled equipment as per relevant standards.

Certified copies of reports of all type tests carried out on similar type and rating of equipment (offered under this contract) within last five years from the date of submission of Bid shall be submitted to the OWNER for review and approval. In case the type test reports are not found to be meeting the specification requirements, the BIDDER shall conduct all such tests under this contract free of cost to the OWNER and submit the reports for approval.

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Copies of the test certificates for all bought out items and calibration certificates shall be submitted for the OWNER's approval before dispatch of the switchyard equipment.

33.12 Site / Commissioning Tests

Site tests shall include all tests to be carried out at site on various equipment. They shall include but not be limited to calibration tests, configuration tests and commissioning tests. The BIDDER shall be responsible for all site / commissioning tests. All necessary testing equipment required for testing and commissioning shall be arranged by the BIDDER.

The BIDDER shall maintain all tests, calibration records in owner approved formats, and these shall be countersigned by authorized quality control personnel of the BIDDER supervising these works.

33.13 Erection and Installation

BIDDER shall supply all the instruction manuals necessary to perform erection, testing & commissioning, operation and maintenance activities. All the major equipment shall be installed, tested and commissioned under supervision of representative of original manufacturer of respective equipment. Notes and details attached with this specification to be followed for all installation works.

The instructions shall include full details and procedure for installation of the equipment and all necessary adjustments during service and operation, together with part lists to enable spare part or replacements to be ordered.

33.14 Employer's Specifications

Sl No.	Description	Units	Client's Specification
1	**132 kV Switchyard**		
1.1	Nominal voltage	kV	132
1.2	Highest System voltage	kV	145
1.3	Frequency	Hz	50
1.4	Short circuit current	kA (rms)	40 kA for 1 sec.
1.5	Lightning Impulse withstand voltage	kV (Peak)	650
1.6	One minute power frequency withstand voltage	kV (rms)	275
1.7	Switching impulse withstand	kV (Peak)	-
1.8	Reference ambient temperature	°C	50
1.9	Creepage distance	mm	31 mm/kV based on highest system voltage
1.10	Minimum Clearances		
i)	Phase to phase (min)	mm	1300
ii)	Phase to earth (min)	mm	1300
iii)	Sectional clearance	mm	3800
iv)	Ground clearance	mm	4800
2	**132 kV Outdoor Bus**		
2.1	Nominal voltage, phases and frequency	V, Ph, Hz	132000 / 3 / 50
2.2	System neutral earthing		Non Effectively
2.3	Maximum system voltage	V	145000
2.4	Type of breaker		Vacuum / SF_6
2.5	One minute power frequency withstand voltage	kV(rms)	As per Standard
2.6	1.2/50 microsecond impulse withstand voltage	KV (peak)	As per Standard
2.7	Bus bar support insulator	kV	145
2.8	Bus bar rating	A	Refer SLD
2.9	Short circuit current rating and duration		40 kA, 1 Sec.
3	**Circuit Breaker**		
3.1	Circuit breaker type		SF_6
3.2	Rated current	A	1600

Sl No.	Description	Units	Client's Specification
3.3	Short circuit withstand current and duration	kA (rms) Sec	40 for 3 Sec
3.4	Making current	kA (Peak)	
3.5	Breaking capacity of line charging current	A	
3.6	Breaking capacity of magnetising current	A	
3.7	Short circuit making current of earthing switch	kA (Peak)	40 for 3 Sec
3.8	Voltage, frequency and No. of phases	kV, ph, Hz	145000 / 50 / 3
3.9	Rated operating duty		O-3min-CO-3min-CO
3.1	Total opening time		3 cycles
3.11	Total closing time		5 cycles
3.12	Trip free operating mechanism type		Motor charged spring. Manual trip and close facility to be provided.
3.13	Short circuit current rating and duration		40 kA 1 Sec
3.14	Auxiliary control voltage :		
	For closing / tripping coil /spring charging motor	V, DC	220V +10% volts
	For space heaters and lighting and plug point	V, Phase	240V +10%, 1 phase
4	**Current Transformer**		
4.1	Quantity	Nos	3
4.2	Type		Cast resin bar primary
4.3	System voltage and frequency	V, Hz	145000 / 50
4.4	Class of insulation		Class 'B' or better
4.5	Short circuit withstand current and duration		40 kA for 1 sec
4.6	Rated Primary current & ratio		600-300/1-1-1-1-1 A
4.7	Accuracy class & Burden		As per SLD
4.8	Junction Box		Require
5	**Capacitor Voltage Transformer**		
5.1	Type		Cast resin
5.2	Quantity	Nos	3
5.3	Rated voltage		

Sl No.	Description	Units	Client's Specification
i)	Primary	V	145000 /√3
ii)	Secondary	V	110/√3 / 110/√3
5.4	Method of connection		
i)	Primary		Star earthed
ii)	Secondary		Star / Open
5.5	Rated voltage factor		1.2 Continuous & 1.9 for 30secs
5.6	Class of insulation		Class 'B' or better
5.7	Accuracy Class		Metering – 0.2 Protection – 3P
5.8	Burden		As required
5.9	Junction Box		Require
6	**Isolators**		
6.1	Quantity	Nos	4
	With earth switch	Nos	2
	Without earth switch	Nos	2
6.2	Type		Double Break
6.3	Execution of poles		
6.4	Rated current	A	1600
6.5	Short circuit withstand current and duration	kA (rms) Sec	40 for 3 Sec
6.6	Material of main contact		Copper
6.7	Whether contacts are to be silver faced		Yes
6.8	Operating device (motor / manual		
i)	Main disconnector		Motor and Manual
ii)	Earth switch		Motor and Manual
6.9	Emergency operation		
i)	Main disconnector		Require
ii)	Earth switch		Require
6.10	Support insulators		Require
6.11	Type of insulator (Pedestal / Solid / Polycone etc.)		

Sl No.	Description	Units	Client's Specification
6.12	Nominal creepage distance	mm	31
6.13	Minimum strength		
6.14	Torsoinal	Nm	
6.15	Minimum cantilever strength	kgs	
6.16	Miscellaneous		
6.17	No. of NO & NC aux. Contacts for purchaser's use (main and earth switch)	Nos	10
6.18	Pole discrepancy circuit required	Yes / No	
6.19	Purchaser's earthing conductor (material & size)	mm x mm	
6.20	Mounting structure included in vendor's scope of supply	Yes / No	
6.21	Phase to phase spacing of poles	mm	
6.22	Height of connection/bus above ground level	mm	
6.23	Clamps and connectors		
6.24	By purchaser/vendor		
6.25	Take off (Horz, Vert, etc)		
6.26	Conductor size and material		
6.27	Auxiliary supply		
6.28	Electrical		220VDC /240VAC
6.29	Type of interlock		Electrical and Mechanical
6.30	Environment : salty / dusty / normal/ corrosive / polluted		Normal
6.31	Wind pressure	kg/Sq.m	
6.32	Coefficient of seismic acceleration		
6.33	Altitude above M.S.L.	Mtr	
6.34	List of type tests to be carried out		
6.35	Junction Box		Require
6.36	Spares		
6.37	Support insulator column		Require
6.38	Operating rod insulator		Require
6.39	Drive motor		Require
	Motor contactor of each type		Require

Sl No.	Description	Units	Client's Specification
	Fuses of each rating		Require
	Spring		Require
7	**Lightning Arrestors**		
7.1	Quantity	Sets	3
7.2	Installation		Structure Mounted
7.3	System voltage		
i)	Nominal	kV	132
ii)	Highest	kV	145
7.4	System Earthing		Ungrounded
7.5	Type of arrester		
7.6	Short circuit current at arrester location	kA	40
7.7	Maximum duration of earth fault	Sec	3
7.8	Co-efficient of earthing		
7.9	Temperature limits		
7.1	Seismic requirement		
7.11	Wind velocity		
7.12	Variation in frequency		
7.13	Rated values		
7.14	Rated arrester voltage / maximum continuous operating voltage	kV	
7.15	Discharge class		4

33.15 Applicable Standards

Sl. No.	Title	Reference Standard	
1	Specification for wrought aluminium and aluminium alloy bars, rods, tubes and selections for electrical purposes	IS 5082	IEC
2	Circuit breakers	IS 13118	IS/IEC 62271-100
3	Insulators	IS 2544	IEC 273
4	Large hollow porcelains	IS 5621	IEC 233
5	Electrical power connectors	IS 5561	IEC
6	Hot dip galvanizing	IS 2629 IS 2633	IEC
7	Guide for testing of circuit breakers for out-of-phase switching	IS 9135	IEC
8	SF6 Gas	IS	IEC 376
9	Isolators	IS 9921	IEC 129 and IEC 694
10	Current transformers	IS 2705	IEC
11	Bushings	IS 2099	IEC 137
12	Voltage transformer	IS 3156	IEC
13	Coupling capacitors and capacitor dividers	IS 9348	IEC 358
14	Capacitor voltage transformer	IS 3156, PART - IV	IEC 186
15	Electrical relays for power system protection	IS 3231	IEC
16	Specification for static protective relays	IS 8686	IEC
17	Lightning arrester	IS 3070	IEC 99
18	Suspension insulators	IS 731	IEC
19	Insulator fittings	IS 2486	IEC
20	High voltage fuse	IS 9385	IEC 60282-2
21	Low voltage fuse	IS 9224	IS/IEC 60947-3
22	Boards blanks for sley bottom, race, cap and box back of cotton looms	IS 9794	IEC
23	Circuit breakers		IS/IEC 62271-100
24	Metal enclosed switchgear	IEC 62271-200	
25	Current transformers	IS 2705	IEC 61869-2
26	Voltage transformers	IS	IEC 61869-3
27	Arrangement for switchgear busbars, main connections and auxiliary wiring	IS 5578 / IS 11353	
28	Busbar support insulators	IS 2544	IEC 60273

Sl. No.	Title	Reference Standard	
29	Degree of protection	IS/IEC 60529	
30	Electrical relays for power system protection	IS 3231	IEC 60255
31	Electrical indicating instruments	IS 1248	IEC 60051
32	High voltage fuses	IS 9385	IEC 60282
33	AC. electricity meters	IS 1595	IEC 60359
34	Aluminium busbars	IS 5082	IEC 60105
35	Code of practice for phosphating iron and steel	IS 6005	IEC 255
36	AC disconnectors and earth switches	IS/IEC 62271-102	
37	Low voltage fuses	IS/IEC 60947-3	

CHAPTER 34: ELECTRICAL SYSTEM DESCRIPTION

34.1 Introduction

The Khorlochhu (600 MW) (HPP) consists of units as indicated below. Power shall be generated at 13.8 kV and connected to 420 kV Potheadyard by means of XLPE cables through 420 kV GIS. The power shall be evacuated through two 400kV outgoing feeders and 400/132kV ICT Transformer.

Refer following Drawings the Khorlochhu (600 MW): 4 x 150 MW

34.1.1 Single Line Diagram.

i) KHPP-EL-PH-SLD-4006-AU-40001- Key Single Line Diagram

ii) KHPP-EL-PH-SLD-4006-AU-40002-Metering and Protection System Single Line Diagram

iii) KHPP-EL-PH-SLD-4006-AU-40003 - MV & LV System Single Line Diagram

iv) KHPP-EL-PH-SLD-4006-AU-40004-Korlung-132kV Feeder Single Line Diagram

v) KHPP-EL-PH-SLD-4006-AU-40005 - DC System Single Line Diagram

vi) KHPP-EL-PH-4006-AU-40006-400kV Potheadyard Layout

34.1.2 SCADA Architecture

i) SCADA Architecture for Plant Automation (KHPP-IC-PH-4006-AU-40007)

34.2 System Design

The electrical system shall be designed to provide:

i) Safety to personnel and equipment during the operation and maintenance

ii) Reliability of service

iii) Minimum fire risk

iv) Ease of maintenance and convenience of operation

v) Automatic protection of all electrical equipment through selective relaying system.

vi) Electrical supply to equipment and machinery within the design operation limits.

vii) Adequate provision for future extension and modifications.

viii) Fail safe features.

ix) Suitability for applicable environmental factors.

x) Maximum interchangeability of equipment.

xi) Segregate electrical supply to essential/non-essential equipment

xii) The latest versions of the following statutory regulations shall be followed for the design of electrical systems.

xiii) Indian Electricity Act.

xiv) CEA Regulation.

xv) CBIP

xvi) CEIG requirement.

xvii) National Electrical Code & National Building Code (NBC)

xviii) Local Electricity board

xix) The factory Act.

xx) Additional standards refer in respective section of each equipment's Data sheet-A.

The scope of work of the Contractor shall include getting statutory approval of the electrical installation from State electrical inspectorate & any statutory bodies required to commission the project.

The Installation work shall be carried out by an electrical contractor holding a valid license as required by the state government. The installation shall require approval of the Chief Electrical Inspector to the government of respective state & the contractor shall prepare all necessary drawings / documents, in obtaining the approval for successful commissioning of the system.

Generator and its excitation system shall have capability of 10% continuous overload and match the declared maximum continuous rated output/capacity of the associated turbine and shall be capable of continuous stable operation without any excessive temperature rise at the peak output/capacity of the associated turbine under overload. Excitation system should have 100% redundancy with Thyristor Bridges. Spares and services support to be provided for 15 years.

The design of plant auxiliary systems and equipment shall ensure satisfactory operation under variations of voltage ±10%, frequency (+) 5% to (-) 5%, combined voltage and frequency 10% for A.C., -15% to +10% for DC as may be met under operating conditions, including those due to starting loads and short circuit and other fault conditions. However, voltage & frequency variations of Generator & Generator circuits shall be followed as mentioned in the Generator data sheet-A.

The design ambient temperature for all electrical equipment shall be 50°C for both indoor and outdoor equipment's and relative humidity of 95% shall be considered.

If Generator voltage is modified based on the manufacturer recommendation to have a techno commercial advantage, then same shall be indicated as an optional price including all other related equipment parameters to suit the modified Generator voltage. Purchaser / Purchaser Engineer will decide the suitable design during the Tender evaluation and communicated to bidder.

The maximum voltage drop in various parts of electrical system under steady state conditions at full load shall be within the limits stated below:

Sl. No.	System Element	Maximum Permissible Voltage Drop
1	Cable between 415V Service Transformer terminal and MCC	0.5%
2	Cables between MCC and motor	3%
3	Cables between MCC and lighting DB	1 to 1.5%
4	Cables between lighting panels and lighting points	3%
5	DC supply circuits (Between the Battery terminal to load end)	5%
6	Service Transformer LT Terminal to load end	5%
7	UPS outgoing circuits (Between the UPS terminal to load end)	5%

Provision of measurement and recording of Auxiliary consumptions at all the distribution levels shall be provided & ensured.

All the plant equipment and associated auxiliary systems including their operation and monitoring shall be automated considering unmanned operation, with required redundancies & 100% remote operation of the lowest level of equipment shall be considered.

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The local control panels should have the capability to switch on and off auxiliaries independent of the Plant SCADA / PLC system.

Commitment to spares and service support for the next 15 years to be considered.

34.3 Scope

The broad scope of design, engineering, manufacture, inspection and testing at manufacturer's works, supply, packing and forwarding, delivery to site, unloading from carriers / wagons, storing at site (includes scope of making storage yard/ warehouse), transport to erection site, erection, testing and commissioning at site, carrying out performance / acceptance test, comprehensive insurance till the equipment / system is handed over after commissioning of electrical equipment covered under this contract are as follows for each project.

i) Generator and complete auxiliaries with static excitation system, local & remote control panels, all auxiliary drive motors, local push button stations, etc.

ii) Isolated Phase Busduct (IPBD) & accessories along with neutral grounding transformer & resistor, dynamic braking switch for each unit.

iii) LAVT, Brake Disconnector with all necessary equipment & accessories, etc. required for Plant operations.

iv) Generator transformer for power evacuation/drawl along with all necessary equipment & accessories, etc.

v) Unit/station Transformers along with all necessary equipment & accessories, etc. for plant inhouse power distributions.

vi) 3-phase, 80 MVAr Shunt reactor for 400 kV system.

420 kV GIS substation for power evacuation/drawl along with all necessary equipment & accessories, etc. (GT bay-4 Nos, ICT bay-1 No, Shunt reactor Bay- 1No, Line Bay-2 Nos, Bus coupler-1 Nos, Bus PT-2 Nos, Double bus arrangement). (Please refer overall key SLD for GIS bay requirement.)

i) 420 kV Pothead yard along with all necessary equipment & accessories, etc.

ii) MV Indoor Switchgears, Unit/Station/Service transformers, Segregated / Non-Segregated phase busduct (SPBD/NSPBD), 415V switchgear and distribution boards for complete plant.

iii) IPBD for 13.8 kV circuits and NSPBD for 415V Auxiliary / service transformer circuits along with all accessories.

iv) Complete Control & Protection with Metering, Indication for entire plant including GIS & pothead yard.

v) Synchronizing panel complete with auto synchronizer, manual synchronizing equipment for the generator and plant auxiliary system.

vi) 220V V DC system complete with battery, battery health monitoring system, chargers and distribution boards for the Power plant as well as GIS.

vii) 230 V AC UPS with batteries for the power plant as well as GIS.

viii) Motors & Motorized valves for the Plant requirement

ix) Plant Communication system (PCS) & Public Addressing (PA) system

x) Fiber optical terminal equipment (FOTE) / Optical Line Terminal Equipment (OLTE) for Plant end, Grid station end.

xi) MV & LV Power, control and instrumentation cables and cable carrier system for entire power plant including GIS & pothead yard. In addition, it includes the scope of cabling from power plant to DAM control room, Valve house control room , surge shaft gate & Chaplangchhu Intake.

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xii) EHV cables & terminations, as required.

xiii) Grounding mat, Earthing and lightning protection system for entire power plant including GIS & pothead yard.

xiv) Plant Indoor and Outdoor lighting system for entire power plant including GIS & pothead yard.

xv) Fire Detection & Alarm system (FDA) for entire power plant including GIS & pothead yard shall be as per NFPA guidelines & local statutory regulations.

xvi) Emergency Diesel Generator set with Auto synchronizing & AMF facility. Remote monitoring and control facility for DG set to be considered.

xvii) Passenger Cum Goods Elevator

xviii) DAM Electrical system includes complete items / systems of MV/LV system, transformer, DC & UPS system, cables & cable carrier system, earthing & Lightning, lighting, FDA, PCS, PA, DG set, OFC, etc.

xix) Chaplangchhu Diversion Intake electrical system includes complete items / systems of MV/LV system, transformer, DC & UPS system, cables & cable carrier system, earthing & Lightning, lighting, FDA, PCS, PA, DG set, OFC, etc.

xx) Valve house electrical system includes complete items / systems of MV/LV system, transformer, DC & UPS system, cables & cable carrier system, earthing & Lightning, lighting, FDA, PCS, PA, DG set, OFC, etc.

xxi) Grid station end control room - electrical system includes ACDB, UPS system, cables & cable carrier system, earthing & Lightning, lighting, FDA, PCS, PA, OFC, etc.

xxii) Electrical Workshop with required accessories.

xxiii) Mandatory spares

xxiv) Commissioning spares

xxv) Recommended spares for five (5) years

xxvi) Tools & tackles

xxvii) Testing equipment & instruments.

xxviii) Construction power supply & Water.

The scope shall include all parts, accessories which are essential for construction, operation and maintenance of the complete HPP plant, even though these are not individually / specifically stated.

34.4 Terminal Points

Terminal point at pot head yard gantry structure for takeoff /connection of transmission line system including FOTE.

DAM Gates, Tailrace Gates & Surge Shaft Gates: Incoming power / control at Motor terminals / Local Control Panel

At Grid station: FOTE connected at Transmission line tower/gantry & Grid station's communication, control, & protection system.

34.5 Exclusions

i) All civil works other than exclusively mentioned in scope.

ii) Transmission lines.

iii) Civil works of earth pits, Cable trench, Brick masonry for earth pit & Trench works (Excavation & Filling) for Earth grid.

iv) OPGW cable for FOTE.

34.6 Layout Requirement

Preliminary layouts of powerhouse and plot plan are enclosed with the specification for guidance.

The location for control relay panels, MV switchgear panels, Auxiliary transformer, 415V switchgear, DC switchgear, battery and chargers, UPS etc. have been shown indicatively in the powerhouse GA drawing in various locations / control blocks. All the cabinets / panels shall have the same height, depth and color. The location of GIS, switchyard, GT, ICT transformers, unit/station transformers, overhead line terminating structures etc. is identified in the layout drawing as shown. However same shall be modified to suit layout requirements during detailed engineering.

All the electrical equipment, panels etc shall be physically segregated based on the units and as specified in the scope. Switchgear and control room layout shall be designed such that all the panels related to each unit shall be grouped in one location and GIS panels shall be located in one location as required. Battery shall be located in a separate room.

Control and monitoring of GIS, Pothead yard, MV panel, DG set & necessary 415 V incomers/outgoing feeders shall be done from the plant control room itself.

Equipment layout shall consider fulfilment of statutory requirements apart from the specification requirements.

Fireproof fittings and accessories in the battery room.

List of drawings & documents to be submitted along with bid refer Chapter 64.

List of drawings & documents to be developed & furnished by the vendor / contractor / bidder after award of contract.

Khorlochhu Hydro Power Ltd.

KHORLOCHHU HYDRO POWER LIMITED

4x150 MW KHORLOCHHU HYDROPOWER PROJECT

TRASHIYANGTSE; BHUTAN

BIDDING DOCUMENT

FOR

CONTRACT PACKAGE: KEM-1

DESIGN, MANUFACTURING, SUPPLY, INSTALLATION, TESTING AND COMMISSIONING OF ELECTRO-MECHANICAL WORKS

VOLUME - 4

EMPLOYER'S REQUIREMENTS

QUALITY ASSURANCE PLAN (QAP)

International Competitive Bidding

These documents are meant for the exclusive purpose of bidding against this NIT and shall not be transferred, reproduced or otherwise used for purposes other than that for which they are specifically issued.

Tender Ref. No. KHPL/C&PD/TENDER:KEM-1/2025/11534 dt. 07.08.2025

LAYOUT OF BIDDING DOCUMENTS

CONTRACT PACKAGE: KEM-1

Design, Manufacturing, Supply, Installation, Testing and Commissioning of Electro-Mechanical Works

Volume - 1: Instructions to Bidders (ITB)

- **Section - 1** Abridged Notice Inviting Tender and Notice Inviting Tender (NIT)
- **Section - 2** Instructions to Bidders (ITB), Bid Data, Qualification Forms, Information for Bidders (IFB) and Work Schedule

Volume - 2: General Conditions of Contract (GCC) and Particular Conditions of Contract (PCC)

- **Section - 3** FIDIC General Conditions of Contract (GCC) for Plant and Design-Build Contract (First Edition 1999)
- **Section - 5** Forms and Procedures
  - Form-1: Letter of Tender
  - Form-2: Form of Contract Agreement
  - Form-3: Bank Guarantee Form for Performance Security
  - Form-4: Bank Guarantee Form for Advance Payment
  - Form-5: Form of Taking Over Certificate
  - Form-6: Bank Guarantee Form for Release of Retention Money
  - Form-7: Hindrance Register
  - Form-8: Dispute Adjudication Agreement
  - Form-9: Parent/Holding Company Agreement
  - **Form-10: Proforma for Joint Deed of Undertaking**

Volume-3: Price Schedules

Volume-4: Employer's Requirements

- **Section - 6** General Technical Specifications (GTS)
- **Section - 7** Particular Technical Specifications (PTS)
- **Section - 8** Quality Assurance Plan (QAP)

Volume-5: Tender Drawings

Volume-6: Technical Data Sheets

Khorlochhu Hydro Power Ltd.

SECTION – 8
QUALITY ASSURANCE PLAN
(QAP)



1.0 QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO ENERGY LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.1 Pelton Turbine - Injector, Brake Jet and Deflector (Sheet 1 of 2)

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
1.	**Raw Material**								
1.1	**Nozzle Body, Nozzle, Needle, Needle Tips, Seat Ring, Adjusting Ring, Deflector, Deflector Shaft & Fasteners etc.**								
a)	Chemical Analysis	Chemical	Sample	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
b)	Mechanical Properties	Mechanical	Sample	-do-	TC	3/2	-	1	TC
c)	NDT of Cast/Forged steel	UT	100 %	-do-	TC	3/2	-	1	TC
1.2	**Deflector – Bearing**								
a)	Chemical Analysis	Chemical	Sample	-do-	TC	3/2	-	1	TC
b)	Mechanical Properties	Mechanical	Sample	-do-	TC	3/2	-	1	TC
1.3	**Nozzle Spring**								
a)	Mechanical Properties	Mechanical	Sample	-do-	TC	3/2	-	1	TC
2.	**In-process Inspection**								
a)	Welding as applicable								
i)	Fillet welds - NDT	MPI/DPT	100 %	-do-	TC	3/2	-	1	TC
ii)	Full strength welds - NDT	X-Ray/UT	100 %	-do-	TC	3/2	-	1	TC

Note: a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used- RR - Review of Records, T.C.-Test Certificate Submission, JIR - Joint Inspection Report & CHP-Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT: KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.1 Pelton Turbine - Injector, Brake Jet and Deflector (Sheet 2 of 2)

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
b)	HVOF Tungsten carbide coating (Needle Tips & Seat Ring) - thickness	Measurement	100%	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
c)	Machining Dimension	Measurement	100%	-do-	IR	3/2	-	1	RR
3.	**Final Inspection**								
3.1	**Injector (Nozzle) Assembly, Brake Jet & Deflector System**								
a)	Dimensional & Stroke Check	Measurement	100%	-do-	JIR	3/2	-1	-	CHP
b)	Surface finish – Machined surface	Visual / Measurement	100%	-do-	JIR	3/2	-1	-	CHP
c)	Hydraulic Test – Nozzle Servomotor Cylinder, Nozzle Body & tip	Test	100%		JIR	3/2	1		CHP
d)	Operational Test						1		
i)	Alignment & free movement of needle with servomotor	Visual	100%	-do-	JIR	3/2	-1	-	CHP
ii)	Needle opening & closing with servomotor	Visual	100%	-do-	JIR	3/2	-1	-	CHP
iii)	Nozzle Servomotor - Stroking	Visual	100%	-do-	JIR	3/2	-1	-	CHP
iv)	Free Movement of Deflector with servomotor	Visual	100%	-do-	JIR	3/2	-1	-	CHP
e)	Verification of Technical Requirement of Drawing	Visual	100%	-do-	JIR	3/2	-1	-	CHP
f)	Painting & Preservation	Visual/Measurement	100%	-do-	TC	3/2	-	-1	TC

Note: a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used- RR - Review of Records, T.C.-Test Certificate Submission, JIR - Joint Inspection Report & CHP-Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT: KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.2 **Pelton Turbine – Distributor** (Sheet 1 of 2)

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
1.	**Raw Material**								
1.1	**Steel Plate**								
a)	Chemical Analysis	Chemical	Sample	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
b)	Mechanical Properties	Mechanical	Sample	-do-	TC	3/2	-	1	TC
c)	NDT of Plate	UT	100%	-do-	TC	3/2	-	1	TC
2.	**In-process Inspection**								
a)	Welding as applicable								
i)	Fillet welds - NDT	MPI/DPT	100%	-do-	TC	3/2	-	1	TC
ii)	Full strength welds - NDT	UT/X-Ray	100%	-do-	TC	3/2	-	1	TC
b)	Stress Relieving after welding	Temperature Regulation	100%	-do-	IR	3/2	-	1	RR
c)	Machining Dimension	Measurement	100%	-do-	IR	3/2	-	1	RR
d)	Distributor Segment - Matching of Flanges	Visual/Measurement	100%	-do-	IR	3/2	-	1	RR
3.	**Final Inspection**								
a)	Hydrostatic Pressure Test	Test	100%	-do-	JIR	3/2	1	-	CHP
b)	Dimensional & Layout Check	Visual/Measurement	100%	-do-	JIR	3/2	1	-	CHP

Note: a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT: KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.2 Pelton Turbine – Distributor (Sheet 2 of 2)

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
a)	Matching / Fitment of Access Door assembly with Body	Visual/Measurement	100%	Approved Drawings/Technical Spec./Relevant Standard	JIR	3/2	1	-	CHP
b)	Verification of Technical Requirement of Drawing Painting & Preservation	Visual/Measurement	100%	-do-	JIR	3/2	1	-	CHP
c)	Matching / Fitment of Access Door assembly with Body	Visual/Measurement	100%	-do-	TC	3/2	-	1	TC

Note: a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used -RR - Review of Records, T.C.-Test Certificate Submission, JIR - Joint Inspection Report & CHP-Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

Khorlochhu Hydro Power Ltd.

QUALITY ASSURANCE PLAN (MODEL)

PROJECT: KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.3 **Pelton Turbine – Turbine shaft** (Sheet 1 of 2)

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
1.	**Raw Material**								
1.1	**Forged Steel**								
a)	Chemical Analysis	Chemical	Sample	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
b)	Mechanical Properties (Radial and Tangential)	Mechanical	Sample	-do-	TC	3/2	-	1	TC
c)	NDT of Shaft	UT (Radial & Axial Direction)	100%	-do-	TC	3/2	-	1	TC
1.2	**Coupling Bolts**								
a)	Chemical Properties	Chemical	Sample	-do-	TC	3/2	-	1	TC
b)	Mechanical Properties	Mechanical	Sample	-do-	TC	3/2	-	1	TC
c)	Proof Load Test	Test	100%	-do-	TC	3/2	-	1	TC
2.	**In-process Inspection**								
2.1	Heat treatment	Temperature Regulation	100%	-do-	IR	3/2	-	1	RR
2.2	Baroscopic examination of shaft bore	Visual	100%	-do-	TC	3/2	-	1	TC
2.3	Dimensional examination	Measurement	100%	-do-	TC	3/2	-	1	TC

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.3 Pelton Turbine – Turbine Shaft (Sheet 2 of 2)

NIT/P.O. REFERENCE :

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record of Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
3.	**Final Inspection**								
3.1	Run out check of Turbine Shaft	Measurement	100%	Approved Drawings/Technical Spec./Relevant Standard	JIR	3/2	1	-	CHP
3.2	Dimension check for Shaft	Measurement	100%	-do-	JIR	3/2	1	-	CHP
3.3	Coupling holes & Bolt – Dimension & Interchangeability check	Visual/Measurement	100%	-do-	JIR	3/2	1		CHP
3.4	Convexity & Concavity of flanges	Measurement	100%	-do-	JIR	3/2	1	-	CHP
3.5	Surface finish check of Bearing Journal & Flanges	Measurement	100%	-do-	JIR	3/2	1	-	CHP
3.6	Trial assembly of Shaft with Runner	Visual	100%	-do-	JIR	3/2	1	-	CHP
3.7	Combined runout check of Turbine Shaft with Generator Shaft	Measurement	100%	-do-	JIR	3/2	1		CHP

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.4 **Pelton Turbine – Deflector Servomotor** (Sheet 1 of 2)

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
1.	**Raw Material**								
1.1	**Piston & Cylinder**								
a)	Chemical Analysis	Chemical	Sample	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
b)	Mechanical Properties	Mechanical	Sample	-do-	TC	3/2	-	1	TC
c)	NDT of Cast/weld able Steel	UT/MPI	100%	-do-	TC	3/2	-	1	TC
1.2	**Spring**								
a)	Mechanical Properties	Mechanical	Sample	-do-	TC	3/2	-	1	TC
2.	**In-process Inspection**								
2.1	Stress Relieving	Temperature Regulation	100%	-do-	IR	3/2	-	1	RR
2.2	NDT of weld joints after Stress Relieving	Radiography/UT/DPT	100%	-do-	TC	3/2	-	1	TC
2.3	Dimensional checks after machining	Measurement	100%	-do-	IR	3/2	-	1	RR
2.4	Sub-assembly of Servomotor–Fitment of Component	Measurement	100%	-do-	IR	3/2	-	1	RR
2.5	Hydraulic Pressure Test for Cylinder & Piston	Test	100%	-do-	IR	3/2	-	1	RR

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.4 Pelton Turbine – Deflector Servomotor (Sheet 2 of 2)

NIT/P.O. REFERENCE :

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
3.	**Final Inspection**								
3.1	Dimensional check	Measurement	100%	Approved Drawings/Technical Spec./Relevant Standard	JIR	3/2	1	-	CHP
3.2	Stroke Length	Measurement	100%	-do-	JIR	3/2	1	-	CHP
3.3	Functional testing of Servomotor assembly	Test	100%	-do-	JIR	3/2	1	-	CHP
3.4	Hydraulic Test of Servomotor assembly	Test	100%	-do-	JIR	3/2	1	-	CHP
3.5	Verification of Technical Requirement of Drawing	Visual	100%	-do-	JIR	3/2	1	-	CHP
3.6	Painting & Preservation	Measurement	100%	-do-	TC	3/2	-	1	TC

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

Khorlochhu Hydro Power Ltd.

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.5 **Pelton Turbine – Runner** (Sheet 1 of 2)

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
1.	**Raw Material**								
1.1	**Runner –**								
a)	Chemical Analysis	Chemical	Sample	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
b)	Mechanical Properties	Mechanical	Sample	-do-	TC	3/2	-	1	TC
c)	NDT	UT	100%	-do-	TC	3/2	-	1	TC
2.	**In-process Inspection**								
2.1	Stress Relieving	Temperature Regulation	100%	-do-	IR	3/2	-	1	RR
2.2	NDT after Stress Relieving	UT, MPT & DPT			TC	3/2	-	1	TC
2.3	Dimension & Profile check after Machining	Measurement	100%	-do-	IR	3/2	-	1	RR
3.	**Final Inspection**								
3.1	Dimensional check & Surface finish	Measurement	100%	-do-	JIR	3/2	1	-	CHP
3.2	Static Balancing	Measurement	100%	-do-	JIR	3/2	1	-	CHP
3.3	Bucket Pitch, Thickness & Profile check	Measurement	100%	-do-	JIR	3/2	1	-	CHP

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.5 Pelton Turbine – Runner(Sheet 2 of 2)

NIT/P.O. REFERENCE :

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
3.4	NDT for Finished Surface defects	DPT	100%	Approved Drawings/Technical Spec./Relevant Standard	JIR	3/2	1	-	CHP
3.5	Trial assembly of Runner with Shaft	Visual	100%	-do-	JIR	3/2	1	-	CHP
3.6	Verification of Technical Requirement of Drawing	Visual	100%	-do-	JIR	3/2	1	-	CHP
3.7	Painting & Preservation	Measurement	100%	-do-	TC	3/2	-	1	TC

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.6 Pelton Turbine – Pit Liner

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
1.	**Raw Material**								
a)	Chemical Analysis	Chemical	Sample	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
b)	Mechanical Properties	Mechanical	Sample	-do-	TC	3/2	-	1	TC
2.	**In-process Inspection**								
2.1	Fabrication								
a)	Welding								
i)	Fillet Welds - NDT	DPT	100%	-do-	TC	3/2	-	1	TC
ii)	Full strength welds - NDT	UT	100%	-do-	TC	3/2	-	1	TC
2.2	Dimensional Check	Measurement	100%	-do-	IR	3/2		1	RR
3.	**Final Inspection**			-do-					
3.1	Dimensional check of Assembly	Measurement	100%	-do-	JIR	3/2	1	-	CHP
3.2	NDT – Weld Joint	DPT	10% at Random	-do-	JIR	3/2	1	-	CHP
3.3	Painting & Preservation	Measurement	100%	-do-	TC	3/2	-	1	TC

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Khorlochhu Hydro Power Ltd.

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.7 **Pelton Turbine – Runner Housing** (Sheet 1 of 2)

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
1.	**Raw Material**								
1.1	Turbine Housing								
a)	Chemical Analysis	Chemical	Sample	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
b)	Mechanical Properties	Mechanical	Sample	-do-	TC	3/2	-	1	TC
c)	NDT of Plate	UT	100%	-do-	TC	3/2	-	1	
2.	**In-process Inspection**								
a)	Welding								
i)	Fillet Welds - NDT	DPT	100%	-do-	TC	3/2	-	1	TC
ii)	Full strength welds - NDT	UT	100%	-do-	TC	3/2	-	1	TC
b)	Stress Relieving	Temperature Regulation	100%	-do-	IR	3/2	-	1	RR
c)	Dimensional Check	Measurement	100%	-do-	IR	3/2	-	1	CHP
3.	**Final Inspection**								
a)	Dimensional check	Measurement	100%	-do-	JIR	3/2	1	-	CHP
b)	Proof Assembly – Matching/Alignment of Turbine housing with other component	Measurement	100%	-do-	JIR	3/2	1	-	CHP

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.7 Pelton Turbine – Runner Housing (Sheet 2 of 2)

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
c)	Oil bath – Gravity Test	Visual	100%	Approved Drawings/Technical Spec./Relevant Standard	JIR	3/2	1	-	CHP
d)	Verification of Technical Requirement of Drawing	Visual	100%	-do-	JIR	3/2	1	-	CHP
e)	Painting & Preservation	Measurement	100%	-do-	TC	3/2	-	1	TC

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.8 **Pelton Turbine – Turbine Guide Bearing** (Sheet 1 of 2)

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
1.	**Raw Material**								
1.1	Bearing Segments, Bearing Housing, Plate, Pivot Bolt & Locking Nut								
a)	Chemical Analysis	Chemical	Sample	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
b)	Mechanical Properties	Mechanical	Sample	-do-	TC	3/2	-	1	TC
c)	NDT of Plate	UT	100%	-do-	TC	3/2	-	1	TC
1.2	Babbit Material	Chemical	100%	-do-			-	1	TC
1.3	Chemical Analysis for Cooler tube	Chemical	100%	-do-			-	1	TC
1.4	Pressure Gauges, Switches, Oil Level Indicator								
a)	Make, Type & Calibration	Visual	100%	-do-	TC	3/2	-	1	TC
1.5	Strainer								
a)	Chemical Analysis	Chemical	Sample	-do-	TC	3/2	-	1	TC
b)	Mesh size	Visual/Measurement	100%	-do-	TC	3/2	-	1	TC

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Khorlochhu Hydro Power Ltd.

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.8 Pelton Turbine – Turbine Guide Bearing (Sheet 2 of 2)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
2.	**In-process Inspection**								
2.1	Bearing support/Housing – Filet Welding	DPT	100%	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
2.2	Stress Relieving	Temperature Regulation	100%	-do-	IR	3/2	-	1	RR
2.3	NDT of weld joint before & after Heat Treatment	Radiography/UT/DPT	100%	-do-	TC	3/2	-	1	TC
2.4	Bonding of babbit material on Segment (Bearing pad)	UT	100%	-do-	TC	3/2	1	-	CHP
3.	**Final Inspection**								
3.1	Dimensional check of TGB Assembly & Thickness of babbit material	Measurement	100%	-do-	TC	3/2	1	-	CHP
3.2	Surface defects of babbit material	DPT	100%	-do-	TC	3/2	1	-	CHP
3.3	Hydrostatic Test for Heat Exchanger	Test	100%	-do-	TC	3/2	1	-	CHP
3.4	Proof Assembly. - check of all components of Guide Bearing	Match marking & Alignment	100%	-do-	TC	3/2	1	-	CHP
3.5	Painting & preservation	Measurement	100%	-do-	TC	3/2	-	1	TC

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.9 **Digital Governing System** (Sheet 1 of 4)

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
1.	**Digital Electronic Controller**								
a)	Type, Make and Rating	Visual	100%	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
b)	Range of adjustment	Test	100%	-do-	TC	3/2	-	1	TC
c)	Functional Test for Governor Characteristics/Parameters	Test	100%	-do-	TC	3/2	-	1	TC
1.1	Digital Processor								
a)	Make, Type & Rating	Visual	100%	-do-	TC	3/2	-	1	TC
b)	Performance, Speed, Programme memory, Failure Detector Test	Test	100%	-do-	TC	3/2	-	1	TC
1.2	Human Machine Interface(HMI)								
a)	Make, Type & Rating	Visual	100%	-do-	TC	3/2	-	1	TC
b)	Functional Test	Test	100%	-do-	TC	3/2	-	1	TC
1.3	Power Supply Unit								
a)	Make, Type & Rating	Visual	100%	-do-	TC	3/2	-	1	TC
b)	Routine Test	Test	100%	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.9 Digital Governing System (Sheet 2 of 4)

NIT/P.O. REFERENCE :

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
1.4	PLC Unit for Control Logic I/O, Signal Converter								
a)	Make, Type & Rating	Visual	100%	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
b)	Routine Test	Test	100%	-do-	TC	3/2	-	1	TC
1.5	Terminal Card, Relay, Signal Convertor & other Accessories								
a)	Make, Type & Rating	Visual	100%	-do-	TC	3/2	-	1	TC
b)	Routine Test	Test	100%	-do-	TC	3/2	-	1	TC
2.	Digital Electronic Cubicle								
a)	Lay out and BOM Check	Visual	100%	-do-	JIR	3/2	1	-	CHP
b)	Dimension, Thickness of Sheet & Door Lock Arrangement and Paint Shed	Measurement	100%	-do-	JIR	3/2	1	-	CHP
c)	Scheme & Functional Checking	Measurement	100%	-do-	JIR	3/2	1	-	CHP
3.	Electro Hydraulic Actuator, Pilot/ Servomotor Valve, Relays, Solenoid, DC Switches, Limit Switches, Manifold Blocks								
a)	Make, Type & Rating	Visual	100%	-do-	TC	3/2	-	1	TC

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.9 Digital Governing System (Sheet 3 of 4)

NIT/P.O. REFERENCE :

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
b)	Routine Test	Test	100%	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
c)	Calibration, Setting of Electro Hydraulic Actuator	Test	100%	-do-	JIR	3/2	1	-	CHP
4.	**Valves and Pressure Switches, Manifold Block**								
	Pressure Test	Test	100%	-do-	TC	3/2	-	1	TC
5.	**Auto Clean Strainer**								
a)	Mesh Size	Visual	100%	-do-	TC	3/2	-	1	TC
b)	Functional Test	Test	100%	-do-	TC	3/2	-	1	TC
6.	**Pipes & Fittings**								
	Pressure Test	Test	100%	-do-	TC	3/2	-	1	TC
7.	**Speed Signal Generator/Potential Transformer**			-					
	Routine Test	Test	100%	-do-	TC	3/2	-	1	TC

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

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QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.9 Digital Governing System (Sheet 4 of 4)

NIT/P.O. REFERENCE :

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
8.	Complete Assembly of Governor With Control and Electro- Hydraulic Actuator								
a)	Verification of Items as per Bill of Material & Scheme Check	Visual & Test	100%	Approved Drawings/Technical Spec./Relevant Standard	JIR	3/2	1	-	CHP
b)	Check of Protection Devices	Test	100%	-do-	JIR	3/2	1	-	CHP
c)	Functional Check	Test	100%	-do-	JIR	3/2	1	-	CHP
9.	Centrifugal Type Over Speed Limiter								
	Performance Test	Test	100%	-do-	TC	3/2	-	1	TC
10.	Control and Power Cable								
a)	Make, Type & Rating	Visual	100%	-do-	TC	3/2	-	1	TC
b)	Routine Test	Test	100%	-do-	TC	3/2	-	1	TC
11.	Provision for Interfacing complete Governor System with Plant SCADA System	Visual/Measurement	100%	-do-	JIR	3/2	1	-	CHP

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.10 **Oil Pressure Unit** (Sheet 1 of 4)

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
1.	**Sump Tank**								
a)	Material for Tank								
i)	Chemical Composition	Chemical	100%	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
ii)	Mechanical Strength	Mechanical	100%	-do-	TC	3/2	-	1	TC
b)	NDT of Weld Joints	UT/DPT	100%	-do-	TC	3/2	-	1	TC
c)	No Leak Test for Tank	Test			TC		-	1	TC
d)	Dimensional Check	Measurement	100%	-do-	TC	3/2	-	1	TC
2.	**Pressure Vessel**								TC
a)	Material for Tank								TC
i)	Chemical Composition	Chemical	Sample	-do-	TC	3/2	-	1	TC
ii)	Mechanical Strength	Mechanical	Sample	-do-	TC	3/2	-	1	TC
b)	NDT of Weld Joints	UT/DPT			TC		-	1	TC
c)	Post Weld Stress Relieving	Temperature Regulation	100%	-do-	TC	3/2	-	1	TC
d)	Hydrostatic Pressure Test for Pressure Vessel	Test	100%	-do-	TC	3/2	-	1	TC
e)	Dimensional Check	Measurement	100%	-do-	TC	3/2	-	1	TC

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

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QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.10 Oil Pressure Unit (Sheet 2 of 4)

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
3.	**Pipes & Fittings**								
a)	Chemical Composition	Chemical	Sample	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
b)	Mechanical Strength	Mechanical	Sample	-do-	TC	3/2	-	1	TC
c)	Hydro Static Pressure Test	Test	100%	-do-	TC	3/2	-	1	TC
d)	Dimensional Check	Measurement	100%	-do-	IR	3/2	-	1	RR
4.	**Pressure Gauge, Pressure Switch, Float Switch, Temperature Switch etc.**			-do-	TC	3/2	-	1	TC
a)	Make, Model & Type		100%	-do-	TC	3/2	-	1	TC
b)	Calibration Test		100%	-do-	TC	3/2	-	1	TC
c)	Functional Test		100%	-do-	TC	3/2	-	1	TC
5.	**Unloader Valve, Check Valve, Pilot Valve, Safety Valve, Air Blow-off Valve, By pass Valve, Solenoid Valve and Isolating Valve etc.**			-do-					
a)	Make, Model & Type	Visual	100%	-do-	TC	3/2	-	1	TC
b)	Functional Test	Test	100%	-do-	TC	3/2	-	1	TC
c)	Hydrostatic Pressure Test	Test	100%	-do-	TC	3/2	-	1	TC

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature
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Khorlochhu Hydro Power Ltd.

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(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.10 Oil Pressure Unit (Sheet 3 of 4)

NIT/P.O. REFERENCE :

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
6.	**Oil Pump**								
a)	Make, Model, Type & Capacity	Visual	100%	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
b)	Routine Test	Test	100%	-do-	TC	3/2	-	1	TC
7.	**Electric Motor**								
a)	Make, Type & Rating	Visual	100%	-do-	TC	3/2	-	1	TC
b)	Routine Test	Test	100%	-do-	TC	3/2	-	1	TC
8.	**Strainer**								
a)	Mesh Size	Measurement	100%	-do-	TC	3/2	-	1	TC
b)	Chemical composition	Chemical	Sample	-do-	TC	3/2	-	1	TC
9.	**Oil**								
a)	Make & Type	Visual	Sample	-do-	TC	3/2	-	1	TC
10.	**Complete Assembly of Oil Pressure Unit with Control Panel**								
a)	Dimensional Check	Measurement	100%	-do-	JIR	3/2	1	-	CHP
b)	Capacity	Measurement	100%	-do-	TC	3/2	1	-	CHP

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.10 Oil Pressure Unit (Sheet 4 of 4)

NIT/P.O. REFERENCE :

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
c)	Functional Test/Operational Test of Pumps, Motors, Electromagnetic Valves, Pressure Switch & Accessories.	Test	100%	Approved Drawings/Technical Spec./Relevant Standard	JIR	3/2	1	-	CHP
d)	Pressure Tank Relief Valve setting	Visual	100%	-do-	JIR	3/2	1	-	CHP
11.	**Control Panel**								
a)	Verification of Bill of Material	Visual	100%	-do-	JIR	3/2	1	-	CHP
b)	Functional Test	Test	100%	-do-	JIR	3/2	1	-	CHP
c)	IR & HV Test	Test	100%	-do-	JIR	3/2	1	-	CHP
12.	**Painting & Preservation**	Visual & Measurement	100%	-do-	TC	3/2	-	1	TC

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature
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Khorlochhu Hydro Power Ltd.

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.11 Oil Leakage Unit

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
1.	Leakage Oil Unit (If Required)								
1.1	Pump								
a)	Make, Model & Capacity	Visual	100%	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
b)	Routine Test	Test	100%	-do-	TC	3/2	-	1	TC
1.2	Motor								
a)	Make, Model & Rating	Visual	100%	-do-	TC	3/2	-	1	TC
b)	Routine Test	Test	100%	-do-	TC	3/2	-	1	TC
1.3	Float Switch								
a)	Make, Model & Rating	Visual	100%	-do-	TC	3/2	-	1	TC
1.4	Oil Tank								
a)	Leakage Test	Test	100%	-do-	TC	3/2	-	1	TC
b)	Dimensional Check	Measurement	100%	-do-	TC	3/2	-	1	TC
1.5	Functional Test on Complete Oil Leakage Unit	Test	100%	-do-	TC	3/2	-	1	TC
1.6	Dimensional & BOM Check	Visual & Measurement	100%	-do-	TC	3/2	-	1	TC
1.7	Painting & Preservation	Visual & Measurement	100%	-do-	TC	3/2	-	1	TC

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

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QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.12 **Generator - Stator Frame** (Sheet 1 of 2)

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
A.	**Raw Material (Carbon Steel Plate)**								
i)	Chemical Analysis	Chemical	Sample/Lot	Approved Drawings/Technical Spec./ASTM, IS, EN & JIS	TC	3/2	-	1	TC
ii)	Mechanical properties	Mechanical	-do-	-do-	TC	3/2	-	1	TC
iii)	NDT on Steel Plate	UT	-do-	-do-	TC	3/2	-	1	TC
B.	**In-process Inspection**								
i)	Full Strength Welding (Class-I) as applicable	X-Ray/UT	-do-	Approved Drawings/Technical Spec./ISO:6520 & EN: 26520	TC	3/2	-	1	TC
ii)	Other Welds	DPT	-do-	-do-	TC	3/2	-	1	TC
iii)	Dimensional Check after Machining	Measurement	100%	-do-	TC	3/2	-	1	TC
C.	**Final Inspection**								
i)	Welding Examination	DPT/MPI & UT	10%	-do-	JIR	3/2	1	-	TC
ii)	Sole Plate Mounting Face - Level Checking & Check of Flatness	Measurement	10%	-do-	JIR	3/2	1	-	TC
iii)	Sole Plate - Dimensional & Flatness	Measurement	10%	-do-	JIR	3/2	1	-	TC

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

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QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.12 Generator:-Stator Frame (Sheet 2 of 2)

NIT/P.O. REFERENCE :

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
iv)	Dimensional Check of Stator Frame	Measurement	**10%**	Approved Drawings/Technical Spec./ISO:6520 & EN: 26520	JIR	3/2	1	-	TC
v)	Surface finish of Machined surface	Measurement	10%	-do-	JIR	3/2	1	-	TC
vi)	Flatness Check of Seating Surface of Air Cooler	Measurement	10%	-do-	JIR	3/2	1	-	TC
vii)	Painting	Visual	10%	-do-	JIR	3/2	1	-	TC

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

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(Vendor)

Khorlochhu Hydro Power Ltd.

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.13 Generator – Stator Punching

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
A.	**Raw Material (CRNGO)**								
	Material properties. (Grade of Material, Nominal Thickness, Specific Loss, Magnetic Polarization, Anisotropy of Loss, Stacking Factor, Conventional Density etc.	Visual /Measurement /Electrical	Sample plan	Approved Drawings/Technical Spec./IEC:60404, EN: 10106 & JIS C2552	TC	3/2	-	1	TC
B.	**In process**								
i)	Check of Burr Level in Punching Stacking	Measurement	100%	-do-	TC	3/2	-	1	TC
ii)	Factor Check	Measurement	do	-do-	TC	3/2	-	1	TC
iii)	For Quality of Lamination Varnishing , Thickness & IR Value	Measurement	Samples	-do-	JIR	3/2	1		CHP
iv)	Specific Total Loss	Electrical	-do-	-do-	JIR	3/2	1	-	CHP
v)	Magnetic Polarization	do	do	do	JIR	3/2	1	-	CHP
vi)	Trail Assembly of Punching & Dimensional Checking (Punching Thickness, Waviness, Core Dia , Packet Size & Height)	Measurement	-do-	-do-	JIR	3/2	1	-	CHP

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

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QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.14 Generator – Unwound Stator

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
C.	**Studs & End Plate**								
i)	Material Properties.	Chemical /Mechanical	sample	Approved drawings/Technical Spec./EN & JIS	TC	3/2	-	1	TC
D.	**Core Assembly**					3/2			
i)	Dimensional Checking (Check of Core for Waviness, Core Dia, Packet Size and Height after Assembly)	100%	100%	-do-	JIR	3/2	1	-	CHP
ii)	Core Loss Test And Hot Spot Detection	100%	-do-	-do-	JIR	3/2	1	-	Field Test

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

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Khorlochhu Hydro Power Ltd.

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.15 **Generator – Stator Winding Bars** (Sheet 1 of 3)

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
1.	**Raw Material**								
A.	Copper Strands (Material Grade)								
i)	Chemical Analysis	Chemical	Sampling Plan	Approved drawings/Technical Spec./IS: 191 & 3635 & IEC	TC	3/2	-	1	TC
ii)	Resistivity Test	Electrical	Sampling Plan	-do-	TC	3/2	-	1	TC
B.	Fiber Glass Covered Epoxy Varnish Bonded Rectangular Copper Conductor								
i)	Dimensional Check of Bare & Covered Bar & Insulation Thickness	Measurement	Sampling plan	Approved drawings/Technical Spec./IS: 4685 & 6181 & IEC & BS:4801	TC	3/2	-	1	TC
ii)	Bending , Tensile & Elongation Test	Mechanical	Sampling plan	-do-	TC	3/2	-	1	TC
iii)	Breakdown Voltage Test at Room & Rated Temp	Electrical	Sampling plan	-do-	TC	3/2	-	1	TC
iv)	Core Test	Thermal	Sampling plan	-do-	TC	3/2	-	1	TC
v)	Resistance Measurement	Electrical	Sampling plan	-do-	TC	3/2	-	1	TC

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.15 Generator – Stator Winding Bars (Sheet 2 of 3)

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
2.	**In - Process Inspection**								
A.	After Hot Press								
i)	Transposition Angle	visual	Sampling plan	Approved drawings/Technical Spec./ IEC: 34 & BS:4999	TC	3/2	-	1	TC
ii)	Inter Strand Test	Electrical	100%	-do-	JIR	3/2	1		CHP (5%)
B.	Mika Tape								
i)	Thickness	Measurement	Sample	-do-	TC	3/2	-	1	TC
ii)	Tensile Strength	Mechanical	Sample	-do-	TC	3/2	-	1	TC
iii)	Mica Consumption	Chemical	Sample	-do-	TC	3/2	-	1	TC
iv)	Resin Content (Applicable for Resin Rich)	Chemical	Sample	-do-	TC	3/2	-	1	TC

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.15 Generator – Stator Winding Bars (Sheet 3 of 3)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/ Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
v)	Volatility	Chemical	Sample	Approved drawings/Technical Spec./ IEC: 34 & BS	TC	3/2	-	1	TC
vi)	Break Down Voltage	Electrical	Sample	-do-	TC	3/2	-	1	TC
vii)	Tape Life	Chemical/Thermal	Sample	-do-	TC	3/2	-	1	TC
viii)	Thermal Flow Rate	Chemical	Sample	-do-	TC	3/2	-	1	TC
3.	**Final Inspection**								
i)	Tan Delta Measurement	Electrical	100%	-do-	JIR	3/2	1	-	CHP for 20% & TC for 100%
ii)	Impulse Voltage Withstand Test	Electrical	Sample	-do-	JIR	3/2	1	-	
iii)	HV Test on Straight & Overhang Portion	Electrical	100%	-do-	JIR	3/2	1	-	
iv)	IR after HV Test	Electrical	100%	-do-	JIR			-	
v)	Dimensional & Model Checking	Measurement/Visual	Sample	-do-	JIR	3/2	1	-	

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.16 Generator – Wound Stator

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/ Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
1.	HV Test after placing the Bottom Bars in position in Stator Lot, Test Bottom Bar only	Electrical	100%	Approved drawings/Technical Spec./ IEC:34-1, BS: 4999 part 101 & 144 & IS:4722	JIR	3/2	1	-	CHP
2.	HV Test after placing the Top Bars in position in Stator Slot, Test between Bottom Bar and Top Bar	Electrical	-do-	-do-	JIR	3/2	1	-	CHP
3.	RTD Laying, Continuity Test, HV & IR Test and Resistance Measurement	Visual/Electrical	-do-	-do-	JIR	3/2	1	-	CHP
4.	HV Test on Segments	Electrical	-do-	-do-	JIR	3/2	1	-	CHP
5.	IR and Polarization Factor of Stator Winding of Individual Sector	Electrical	-do-	-do-	JIR	3/2	1	-	CHP

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

Khorlochhu Hydro Power Ltd.

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.17 **Generator – Rotor Rim Assembly** (Sheet 1 of 2)

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
1.	**Rim Punching**								
A.	Raw Material (High Tensile Magnetic Steel Sheet)								
i)	Chemical Analysis	Chemical	Sample	Approved drawings/Technical Spec./ BS:601 part 3, EN:101492, etc.	TC	3/2	-	1	TC
ii)	Mechanical Properties	Mechanical	-do-	-do-	TC	3/2	-	1	TC
iii)	Electrical Properties	Electrical	-do-	-do-	TC	3/2	-	1	TC
B.	Bolts & Nuts								
i)	Material Properties	Chemical/ Mechanical	-do-	-do-	TC	3/2	-	1	TC
C.	Final Inspection								
i)	Visual Inspection	Visual	-do-	-do-	TC	3/2	-	1	TC
ii)	Thickness of punching & Burr level Measurement	Measurement	-do-	-do-	TC	3/2	-	1	TC

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.17 Generator – Rotor Rim Assembly (Sheet 2 of 2)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
iii)	Trial Assembly of rotor rim punching (Inner & Outer Diameter Verification, Slot Width & Depth Measurement, Waviness, Packet Size & Verification of Slots with keys bar)	Visual/Measurement	Sample	Approved drawings/Technical Spec./ BS:601 part 3, EN:101492, etc.	JIR	3/2	1		CHP
2.	**Brake Ring & Fan**								
A.	Raw Materials								
i)	Chemical Analysis & Mechanical properties	Chemical/Mechanical	Sample	Approved drawings/Technical Spec./IS, IEC & BS	TC	3/2	-	1	TC
B.	Final Inspection								
i)	NDT of Welds (Fan)	UT & MP	-do-	-do-	TC	3/2	-	1	TC
ii)	UT of Brake Ring	UT	-do-	-do-	TC	3/2	-	1	TC

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.18 **Generator – Pole Assembly** (Sheet 1 of 2)

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
1.	**Pole Punching, End Plate, Pole Coils & Damper Bars**								
A.	Raw Material (High Tensile Magnetic Steel Sheet &Coppers)								
i)	Chemical Analysis	Chemical	Sample	Approved drawings/Technical Spec./BS:601 part 3, EN:101492, etc.	TC	3/2	-	1	TC
ii)	Mechanical Properties	Mechanical	-do-	-do-	TC	3/2	-	1	TC
iii)	Electrical Properties	Electrical	-do-	-do-	TC	3/2	-	1	TC
B.	End Plate, Nuts & Bolts	Chemical/Mechanical/ Electrical	-do-	Approved drawings/Technical Spec./IS:4722 & BS:4999,IEC: 34, etc.	TC	3/2	-	1	TC
i)	Material Properties			-do-					
C.	Final Inspection								
i)	Visual & Dimensional Check	Electrical	100%	-do-	JIR	3/2	1	-	CHP
ii)	Milivolt Drop Test	-do-	-do-	-do-	JIR	3/2	1	-	CHP
iii)	Inter Turn Test	-do-	-do-	-do-	JIR	3/2	1	-	CHP

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.18 Generator – Pole Assembly (Sheet 2 of 2)

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
iv)	DC Resistance Measurement	Electrical	100%	Approved drawings/Technical Spec./IS:4722 & BS:4999,IEC: 34, etc.	JIR	3/2	1	-	CHP
v)	Impedance Measurement	Electrical	100%	-do-	JIR	3/2	1	-	CHP
vi)	HV & IR Test	Electrical	100%	-do-	JIR	3/2	1	-	CHP

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.19 **Generator – Rotor Spider** (Sheet 1 of 2)

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
A.	**Raw Material (Steel Plate)**								
i)	Chemical Analysis	Chemical	Sample/Lot	Approved drawings/Technical Spec./IEC	TC	3/2	-	1	TC
ii)	Mechanical Properties	Mechanical	-do-	-do-	TC	3/2	-	1	TC
iii)	DNT of Steel Plates	UT	-do-	-do-	TC	3/2	-	1	TC
B.	**In-Process Inspection**								
i)	Full Strength Welds (Class-1)	UT/XT	100%	Approved drawings/Technical Spec./ISO: 6520 & EN: 26520	TC	3/2	-	1	TC
ii)	Other Welds	DPT	-do-	-do-	TC	3/2	-	1	TC
iii)	Post Weld Relieving-Heat Treatment (If Applicable)	Thermal	-do-	-do-	TC	3/2	-	1	TC
iv)	Machining Dimensional Check	Measurement	-do-	-do-	TC	3/2	-	1	TC

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Khorlochhu Hydro Power Ltd.

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.19 Generator – Rotor Spider (Sheet 2 of 2)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
C.	**Final Inspection**								
i)	Welding Examination	DPT/MPI	100%	Approved drawings/Technical Spec./ISO: 6520 & EN: 26520	JIR	3/2	1	-	CHP
ii)	DNT for Machined Surface	DPT	-do-	-do-	JIR	3/2	1	-	CHP
iii)	Machining Dimensional Check	Measurement	-do-	-do-	JIR	3/2	1	-	CHP
iv)	Surface Finish of Machined Surface	Visual /measurement	-do-	-do-	JIR	3/2	1	-	CHP
v)	Flatness Check of Flanges / Gap Check	Measurement	-do-	-do-	JIR	3/2	1	-	CHP
vi)	Painting	Visual	-do-	-do-	JIR	3/2	1	-	CHP

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.20 **Generator – Shaft** (Sheet 1 of 2)

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
A.	**Raw Material**								
i)	Chemical Analysis	Chemical	Sample/Lot	Approved drawings/Technical Spec./DIN/ASTM/IS	TC	3/2	-	1	TC
ii)	Mechanical Properties	Mechanical	-do-	-do-	TC	3/2	-	1	TC
B.	**In-Process Inspection**								
i)	Heat Treatment	Thermal	-do-	-do-	TC	3/2	-	1	TC
ii)	DNT After Heat Treatment (Radial & Axial)	UT	-do-	-do-	TC	3/2	-	1	TC
iii)	Mechanical Properties after Heat Treatment –Axial, Radial, Tangential	Mechanical	sample	-do-	TC	3/2	-	1	TC
iv)	Borescope Examination of Centre Bore	Visual & measurement	100%	-do-	TC	3/2	-	1	TC
v)	DNT After Centre Bore	UT	-do-	-do-	TC	3/2	-	1	TC
vi)	Dimensional Check after Machining	Measurement	-do-	-do-	TC	3/2	-	1	TC

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.20 Generator – Shaft (Sheet 2 of 2)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
C.	**Final Inspection**								
i)	Visual Check	Visual	-do-	Approved drawings/Technical Spec./DIN/ASTM/IS	JIR	3/2	1	-	CHP
ii)	Dimensional Check	Measurement	-do-	-do-	JIR	3/2	1	-	CHP
iii)	Run Out & Flatness	-do-	-do-	-do-	JIR	3/2	1	-	CHP
iv)	Surface Finish	-do-	-do-	-do-	JIR	3/2	1	-	CHP
v)	Check of Coupling Holes with Zig	Visual	do	-do-	JIR	3/2	1	-	CHP
vi)	Interchangeability of Bolts	do	do	-do-	JIR	3/2	1	-	CHP

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.21 Generator – Upper and Lower Bracket

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
A.	**Raw Material**								
i)	Chemical Analysis	Chemical	Sample	Approved drawings/Technical Spec./DIN/ASTM/IS	TC	3/2	-	1	TC
ii)	Mechanical Properties	Mechanical	-do-	-do-	TC	3/2	-	1	TC
B.	**In-Process Inspection**								
i)	Dimensional Check	Measurement	100%	-do-	TC	3/2	-	1	TC
ii)	DNT of Welds	UT/MPI/DPT	-do-	-do-	TC	3/2	-	1	TC
C.	**Final Inspection**			-do-					
i)	Dimensional & Surface Finish Check	Measurement	100%	-do-	JIR	3/2	1	-	CHP
ii)	Welding Examination	UT/MPI/DPT	-do-	-do-	JIR	3/2	1	-	CHP
iii)	Leakage Test Oil Retainer Assembly	Measurement	-do-	-do-	JIR	3/2	1	-	CHP
iv)	Flatness & Level Checking of Sole Plate	-do-	-do-	-do-	JIR	3/2	1	-	CHP
v)	Trial Assembly of Top Bracket	-do-	-do-	-do-	JIR	3/2	1	-	CHP
vi)	Painting	Visual	-do-	-do-	JIR	3/2	1	-	CHP

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.22 Generator – Brake and Jacking

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
A.	**Brake & Jacking System Raw Material (Brake Liner & Seam Less Pipe)**								
i)	Chemical Analysis	Chemical	Sample	Approved drawings/Technical Spec./DIN/ASTM/IS	TC	3/2	-	1	TC
ii)	Mechanical Properties	Mechanical	-do-	-do-	TC	3/2	-	1	TC
B.	**Final Inspection**								
i)	Leakage Test on Air Piping System	pressure	100%	-do-	TC	3/2	-	1	TC
ii)	Leakage Test on Oil Piping System	-do-	-do-	-do-	TC	3/2	-	1	TC
iii)	Functional Check	-do-	-do-	-do-					
C.	**Brake & Jack Control Panel**			-do-	JIR	3/2	1	-	CHP
i)	BOM Verification	Visual	100%	-do-	JIR	3/2	1	-	CHP
ii)	Scheme Check	Electrical	-do-	-do-	JIR	3/2	1	-	CHP
iii)	HV & IR	Electrical	-do-	-do-	JIR	3/2	1	-	CHP

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.23 Generator – Shaft Coupling Bolts

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/ Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
	Coupling Bolts								
A.	**Raw Material**								
i)	Chemical Analysis	Chemical	Sample	Approved drawings/Technical Spec./DIN/ASTM/IS	TC	3/2	-	1	TC
ii)	Mechanical Properties	Mechanical	-do-	-do-	TC	3/2	-	1	TC
B.	**Final Inspection**								
i)	Dimensional Check	Measurement	-do-	-do-	TC	3/2	-	1	TC
ii)	DNT on Bolts	MPI/DPT	-do-	-do-	TC	3/2	-	1	TC

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

Khorlochhu Hydro Power Ltd.

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.24 **Generator – Thrust Bearing** (Sheet 1 of 2)

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
A.	**TB Frame, Pad, Disc, Collar , Material & Spring**								
i)	Chemical Analysis	Chemical	Sample	Approved drawings/Technical Spec./IEC	TC	3/2	-	1	TC
ii)	Mechanical Properties	Mechanical	-do-	-do-	TC	3/2	-	1	TC
iii)	DNT of Cast Part	UT	-do-	-do-	TC	3/2	-	1	TC
iv)	Babbit Material-Chemical	Chemical	-do-	-do-	TC	3/2	-	1	TC
B.	**In-Process Inspection**				TC	3/2	-	1	TC
i)	DNT of Welds on TB Frame	UT/MP/DPT	-do-	-do-	JIR	3/2	1		CHP
ii)	DNT on TB Pad after Babbit Metal	UT/thermal	-do-	-do-	JIR	3/2	1		CHP
iii)	Heat Treatment Producer-Trust Collar	UT	-do-	-do-	TC	3/1		1	TC
iv)	DNT of Thrust Collar After Heat Treatment (Radial & Axial)	Measurement	-do-	-do-	JIR	3/2	1		CHP

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.24 Generator – Thrust Bearing (Sheet 2 of 2)

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
v)	Dimensional	Chemical	Sample	Approved drawings/Technical Spec./IEC	JIR	3/2	1		CHP
vi)	Smoothness Check of Thrust Collar Runner Disc				JIR	3/2	1		CHP
vii)	Run-out Check of Shaft with Thrust Collar Assembly	-do-	-do-	-do	JIR	3/2	1		CHP
C.	**T.B Disc**						1		
i)	Flatness & Parallity of Surface	Measurement	-do-	-do-	JIR	3/2	1		CHP
ii)	Surface Finish of Mirror Surface (Roughness Test)	-do-	-do-	-do-	JIR	3/2	1		CHP
iii)	Match Marking of T.B Bush & T.B Disc	Visual	-do-	-do-	JIR	3/2	1		CHP
iv)	HV & IR on T.B Pads	-do-	-do-	-do-	JIR	3/2	1		CHP
v)	Trial Assembly of T.B Components and Looseness of Thrust Bolts	-do-	-do-	-do-	JIR	3/2	1		CHP

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

Khorlochhu Hydro Power Ltd.

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.25 Generator – Guide Bearing

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
A.	**Raw Material (Supports & Pads)**								
i)	Chemical Analysis	Chemical	Sample plan	Approved drawings/Technical Spec./IS & ASTM	TC	3/2	-	1	TC
ii)	Mechanical Properties	Mechanical	-do-	-do-	TC	3/2	-	1	TC
iii)	DNT of Cast Part of T.B Part	UT	-do-	-do-	TC	3/2	-	1	TC
B.	**Final Inspection**								
i)	UT & DP Test of GB Pads	Visual	100%	-do-	JIR	3/2	1		CHP
ii)	HV & IR Measurement of GB Pad Insulation	Electrical	-do-	-do-	JIR	3/2	1		CHP
iii)	Trial Assembly of Complete Bearing	Visual	-do-	-do-	JIR	3/2	1		CHP
iv)	Dimensional & Surface Finish	Measurement	-do-	-do-	TC	3/1	-	1	TC

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.26 Generator – Slip Ring

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
A.	**Raw Material (Steel)**								
i)	Chemical Analysis	Chemical	Sample Plan	Approved drawings/Technical Spec./IS & ASTM	TC	3/2	-	1	TC
ii)	Mechanical Properties	Mechanical	-do-	-do-	TC	3/2	-	1	TC
iii)	Carbon Brush Material Grade, Size, Current Density Resistivity, etc.	Chemical/Mechanical/ Electrical	-do-	-do-	TC	3/2	-	1	TC
B.	**In-Process Inspection**								
i)	UT of Slip Ring	UT	100%	-do-	TC	3/2	-	1	TC
C.	**Final Inspection**								
i)	Dimensional Check after Machining	Measurement	-do-	-do-	TC	3/2	-	1	TC
ii)	HV & IR Testing of Slip Ring Assembly	Electrical	-do-	-do-	TC	3/2	-	1	TC
iii)	Run-out Measurement	Measurement	-do-	-do-	TC	3/1	-	1	TC

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.27 Generator – Air and Oil Cooler

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
A.	**Raw Material (Steel)**								
i)	Chemical Analysis	Chemical	Sample	Approved drawings/Technical Spec./IS & ASTM	TC	3/2	-	1	TC
ii)	Mechanical Properties	Mechanical	-do-	-do-	TC	3/2	-	1	TC
iii)	Dimensional Check	Measurement	-do-	-do-	TC	3/2	-	1	TC
B.	**Final Inspection**								
i)	Dimensional Check Complete Assembly	-do-	100%	-do-	JIR	3/2	1		CHP
ii)	Hydraulic Test of Assembly	Pressure	-do-	-do-	JIR	3/2	1		CHP
iii)	Trail Assembly of Oil Coolers in Upper and Lower Brackets	-do-	Sample	-do-	TC	3/2	-	1	TC
iv)	Painting	-do-	-do-	-do-	JIR	3/2	1		CHP

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Khorlochhu Hydro Power Ltd.

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.28 **Generator – Instruments/Other Devices** (Sheet 1 of 2)

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
A.	**Instrument**								
i)	Calibration of Over Speed Device at Suppliers Works.	Electrical	100%	Drawings/Technical Spec./IEC	TC	3/2	-	1	TC
ii)	Test of Accuracy and Calibration of TRD,TSD and Dial Type Thermometer	-do--	100%	-do-	TC	3/2	-	1	TC
B.	**Other Items /Device**								
i)	Brake Dust Collection Device	Performance test	100%	-do-	TC	3/2	-	1	TC
ii)	Carbon Dust Collection Device	-do-	100%	-do-	TC	3/2	-	1	TC
iii)	High Pressure Automatic Lubrication System	Hydraulic Test	100%	-do-	TC	3/2	-	1	TC
iv)	Anti – Condensation Heater	Performance Test	100%	-do-	TC	3/2	-	1	TC
v)	Creep Detector	-do-	100%	-do-	TC	3/2	-	1	TC
vi)	Vibration Detector with Alarm and Tripping Contact	-do-	100%	-do-	TC	3/2	-	1	TC

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

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Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.28 Generator – Instruments/Other Devices (Sheet 2 of 2)

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
vii)	Partial Discharge Analyser with Permanent Coupler	Electrical	100%	Drawings/Technical Spec./IEC	TC	3/2	-	1	TC
viii)	Moisture Detection System	Performance test	100%	-do-	TC	3/2	-	1	TC
ix)	Air Gap Monitor/Analyser	-do-	100%	-Do-	TC	3/2	-	1	TC
x)	Speed Measuring Device	-do-	100%	-do-	TC	3/2	-	1	TC
xi)	High Pressure Lubricating System	-do-	100%	-do	TC	3/2	-	1	TC
xii)	Shaft current monitoring device	-do-	100%	-do-	TC	3/2	-	1	TC

Note:
a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature
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(Consultant)

Signature & Seal
(Vendor)

Khorlochhu Hydro Power Ltd.

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.29 **Excitation System** (Sheet 1 of 8)

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
A.	**Bought Out Items**								
1.	**Thyrister, Transistor, PCB, Zener Diode, Heat Sink, Filters, etc.**								
a)	Make and Rating	Visual	100%	Approved Drawings/Technical Spec.	TC	2/3	_	1	TC
b)	Functional Test	Electrical	100%	-do-	TC	2/3	_	1	TC
2.	**Power Supply**			-do-	TC	2/3	_	1	TC
a)	Make and Rating	Visual	-do-	-do-	TC	2/3	_	1	TC
b)	Performance Test	Electrical	-do-	-do-	TC	2/3	_	1	TC
c)	Temperature Cycling Test	Test	-do-	-do-	TC	2/3	_	1	TC
d)	HV Test	Electrical	-do-	-do-	TC	2/3	_	1	TC
3.	**DC Field Circuit Breaker**								
a)	Make and Rating	Visual	-do-	-do-	TC	2/3	_	1	TC

Note: a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.29 Excitation System (Sheet 2 of 8)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
b)	Performance Test	Electrical	100%	Approved Drawings/Technical Spec.	TC	2/3	_	1	TC
4.	**Discharge Resistors**								
a)	Make and Rating	Visual	-do-	-do-	TC	2/3	_	1	TC
b)	Temperature Cycling Test	Electrical	-do-	-do-	TC	2/3	_	1	TC
5.	**Metering Equipment**								
a)	Make and Rating	Measurement	-do-	-do-	TC	2/3	_	1	TC
b)	Class & Accuracy	Visual	-do-	-do-	TC	2/3	_	1	TC
c)	Calibration	Electrical	-do-	-do-	TC	2/3	_	1	TC
d)	Routine Test	Electrical	-do-	-do-	TC	2/3	_	1	TC
6.	**Excitation Cable**								
a)	Make and Rating	Visual	-do-	-do-	TC	2/3	_	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.-Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Khorlochhu Hydro Power Ltd.

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.29 Excitation System(Sheet 3 of 8)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
b)	Routine Test	Electrical	-do-	Approved Drawings/Technical Spec.	TC	2/3	-	1	TC
7.	**Monitoring Devices (If Applicable)**								
a)	Functional Check of Temperature Monitor of Thyristor	Electrical	100%	-do-	TC	2/3	-	1	TC
b)	Thyristor Failure Detection	Electrical	-do-	-do-	TC	2/3	-	1	TC
c)	DC Short Circuit Test	Electrical	100%	-do-	TC	2/3	-	1	TC
d)	Check of AC System Overvoltage and Overcurrent Protection	Electrical	100%	-do-	TC	2/3	-	1	TC
e)	Transient Overvoltage due to Lightning or Switching Surges	Electrical	100%	-do-	TC	2/3	-	1	TC
8.	**Rectifier Cooling Fan**								
a)	Make and Rating	Visual	100%	-do-	TC	2/3	-	1	TC
b)	Routine Test	Electrical	100%	-do-	TC	2/3	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.-Test Certificate Submission, JIR-Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
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QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.29 Excitation System (Sheet 4 of 8)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
B.	**Final Inspection**								
1)	Dimensional Check of Panels, Sheet Thickness & Door Operation	Visual	100%	Approved Drawings/Technical Spec./IEC	JIR	2/3	1	-	CHP
	Panels, Sheet Thickness & Door Operation	Dimension	100%	-do-					
2)	Painting								
	Paint Shade, Finish	Visual	100%	Approved Drawings/Technical Spec./IEEE: 421	JIR	2/3	1	-	CHP
3)	BOM Check	-do-	-do-	-do-	JIR	2/3	1	-	CHP
4)	IR Test	Electrical	-do-	-do-	JIR	2/3	1	-	CHP
5)	HV Test on:								
a)	Main Circuit- Converter and De-excitation Equipment	Electrical	-do-	-do-	JIR	2/3	1	-	CHP
b)	Auxiliary Circuits	Electrical	-do-	-do-	JIR	2/3	1	-	CHP

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR-Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
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Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.29 Excitation System (Sheet 5 of 8)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
c)	Auxiliary circuits	Electrical	100%	Approved Drawings/Technical Spec./IEEE: 421	JIR	2/3	1	-	CHP
6)	Continuity Test	-do-	-do-	-do-	JIR	2/3	1	-	CHP
7)	Scheme & Interlocks Checking	-do-	-do-	-do-	JIR	2/3	1	-	CHP
8)	Functional Check of Discharge circuit and Field Overvoltage Protection	-do-	-do-	-do-	JIR	2/3	1	-	CHP
9)	Functional Check of Field Flashing Circuit Breaker	-do-	-do-	-do-	JIR	2/3	1	-	CHP
10)	Test of the self- excitation point of converter	-do-	-do-	-do-	JIR	2/3	1	-	CHP
11)	Nominal Exciter Response Test	-do-	-do-	-do-	JIR	2/3	1	-	CHP
12)	Positive and Negative Ceiling Voltage & Current Test	-do-	-do-	-do-	JIR	2/3	1	-	CHP

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.29 Excitation System (Sheet 6 of 8)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
13)	**Rectifier & Controller**								
a)	Check of Trigger Pulse Equipment (Firing Modules & Power Supply Fault)	Electrical	-do-	Approved Drawings/Technical Spec./IEEE: 421	JIR	2/3	1	-	CHP
b)	Light Load Test	-do-	-do-	-do-	JIR	2/3	1	-	CHP
c)	Rectifier Leakage Test	-do-	-do-	-do-	JIR	2/3	1	-	CHP
d)	Current Balancing Test of Parallel Branches	-do-	-do-	-do-	JIR	2/3	1	-	CHP
e)	PIV Test on Thyristor	Electrical	Sample	-do-	JIR	2/3	1	-	CHP
f)	Polarity and Phase Relationship	-do-	100%	-do-	JIR	2/3	1	-	CHP
g)	Range and Stability of Rectifier Control	-do-	-do-	-do-	JIR	2/3	1	-	CHP

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.29 Excitation System(Sheet 7 of 8)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
h)	Burnt In Test	Electrical	100%	Approved Drawings/Technical Spec./IEEE: 421	JIR	2/3	1	-	CHP
i)	Check of Redundant Thyrister Stack.	-do-	-do-	-do-	JIR	2/3	1	-	CHP
14)	Functional Check of Protection and Trip Logics				JIR	2/3	1	-	CHP
a)	Shaft Voltage Suppressor, Failure of DVRS, Loss of Regulator, Thyristor Firing Circuit Failure, Field Ground Detector & PT Fuse Failure Detection	-do-	100%	-do-	JIR	2/3	1	-	CHP
15)	Test on DVR								
a)	Regulation Signal Flow Test	-do-	-do-	-do-	JIR	2/3	1	-	CHP
b)	Accuracy Test	-do-	-do-	-do-	JIR	2/3	1	-	CHP
c)	Voltage Regulation Test on No-Load	-do-	-do-	-do-	JIR	2/3	1	-	CHP
d)	Regulation Test Under Over and Under Excitation	-do-	-do-	-do-	JIR	2/3	1	-	CHP

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

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Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.29 Excitation System (Sheet 8 of 8)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
e)	Slip Stabilizer Test	Electrical	100%	Approved Drawings/Technical Spec./IEEE: 421	JIR	2/3	1	-	CHP
f)	Stator and Rotor Current Limiter Test	-do-	-do-	-do-	JIR	2/3	1	_	CHP
g)	Load Angle Limiter Test	-do-	-do-	-do-	JIR	2/3	1	-	CHP
h)	(N-1) Limiter Test	-do-	-do-	-do-	JIR	2/3	1	-	CHP
i)	Check of Reference Auto & Manual Start Stop Sequence Test	-do-	-do-	-do-	JIR	2/3	1	-	CHP
j)	Start / Stop Sequence Test	-do-	-do-	-do-	JIR	2/3	1	-	CHP
k)	Functional Tests in all Relays and other	-do-	-do-	-do-	JIR	2/3	1	-	CHP
16)	Dynamic Braking (If applicable)								
	Operational Sequence Check of Dynamic Braking	-do-	-do-	-do-	JIR	2/3	1	-	CHP
17)	Dual Source Internal Power Supply AC & DC Input	Functional	-do-	-do-	JIR	2/3	1	-	CHP

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Khorlochhu Hydro Power Ltd.

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.30 **Excitation Transformer (Dry Type)** (Sheet 1 of 9)

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
A.	**Raw Materials**								
1)	**Steel for End Frame & Enclosure Sheet.**								
a)	Chemical Composition	Chemical	Sample plan	Approved Drawings/Technical Spec./IS	TC	2/3	-	1	TC
b)	Mechanical Test	Mechanical	-do-	-do-	TC	2/3	-	1	TC
2)	**CRGO Sheets**								
a)	Thickness	Measurement	-do-	Approved Drawings/Technical Spec./IS:3042					
b)	Core Loss Ageing	Electrical	-do-	-do-	TC	2/3	-	1	TC
c)	Test Magnetic	-do-	-do-	-do-	TC	2/3	-	1	TC
d)	Induction	-do-	-do-	-do-	TC	2/3	-	1	TC
3)	**Core**								

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.30 Excitation Transformer (Dry Type) (Sheet 2 of 9)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
a)	Dimensional	Measurement	100%	Approved Drawings/Technical Spec./IS:3042	TC	2/3	-	1	TC
b)	Stacking Factor	-do-	-do-	-do-	TC	2/3	-	1	TC
c)	Iron Loss	Electrical	-do-	-do-	TC	2/3	-	1	TC
d)	Ageing Test	Visual	-do-	-do-	TC	2/3	-	1	TC
e)	Surface Insulation	Electrical	-do-	-do-	TC	2/3	-	1	TC
4)	**Copper Conductor**								
a)	Dimension	Measurement	Sample plan	Approved Drawings/Technical Spec./IS:613 & 7404/IEC: 554 & 4665	TC	2/3	-	1	TC
b)	Tensile Strength	Mechanical	-do-	-do-	TC	2/3	-	1	TC
c)	Hardness	-do-	-do-	-do-	TC	2/3	-	1	TC
d)	Elongation	-do-	-do-	-do-	TC	2/3	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.30 Excitation Transformer (Dry Type) (Sheet 3 of 9)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
e)	Conductivity	Electrical	Sample plan	Approved Drawings/Technical Spec./IS:613 & 7404/IEC: 554 & 4665	TC	2/3	-	1	TC
5)	**Fire Glass Covered Copper Conductor**								
a)	Resistivity	Electrical	100%	Approved Drawings/Technical Spec.	TC	2/3	-	1	TC
b)	Mechanical Test	Mechanical	-do-	-do-	TC	2/3	-	1	TC
6)	**Fibre Glass Sheet**								
a)	Physical Properties	Physical	Sample plan	-do-	TC	2/3	-	1	TC
b)	Mechanical Test	Mechanical	-do-	-do-	TC	2/3	-	1	TC
c)	Electrical Test	Electrical	-do-	-do-	-do-	2/3	-	1	TC
7)	**Fittings & Accessories Bushings**								
a)	Type Test	Electrical	1/Type	Approved Drawings/Technical Spec./IS:2099	-do-	2/3	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.30 Excitation Transformer (Dry Type) (Sheet 4 of 9)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
b)	Routine Test	Electrical	100%	Approved Drawings/Technical Spec./IS:2099	TC	2/3	-	1	TC
8)	**Current Transformer**								
a)	Type Tests	Electrical	1/Type	Approved Drawings/Technical Spec./IS:2705	TC	2/3	-	1	TC
b)	Routine Tests	--do-	100%	-do-	TC	2/3	-	1	TC
9)	**Winding Temperature Indicator**								
a)	Make, Type & Rating	Visual	Sample plan	Approved Drawings/Technical Spec.					
b)	Accuracy of Indication	Electrical	100%	-do-	TC	2/3	-	1	TC
c)	High Voltage Test	-do-	-do-	-do-	TC	2/3	-	1	TC
d)	Alarm & Trip Operation	-do-	-do-	-do-	TC	2/3	-	1	TC
10)	**RTD & PT 100 (Temperature Sensor)**								

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.30 Excitation Transformer (Dry Type) (Sheet 5 of 9)

NIT/P.O. REFERENCE :

Sl.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
a)	Make ,Type, Rating	Visual	100%	Approved Drawings/Technical Spec.	TC	2/3	-	1	TC
b)	Resistance	Electrical	-do-	-do-	TC	2/3	-	1	TC
c)	Measurement Calibration Check	-do-	-do-	-do-	TC	2/3	-	1	TC
11)	**Marshalling Box**								
a)	Dimensions	Measurement	100%	Approved Drawings/Technical Spec.	TC	2/3	-	1	TC
b)	HV Tests	Electrical	-do-	Approved Drawings/Technical Spec./IS:8623					
c)	IR Test	-do-	-do-	CBIP Manual	TC	2/3	-	1	TC
d)	Wiring, Interlock & Sequence Check	-do-	-do-	Approved Drawings/Technical Spec.	TC	2/3	-	1	TC
e)	Degree of Protection	Paper Insertion Test	-do-	Approved Drawings/Technical Spec./IS:13947	TC	2/3	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.30 Excitation Transformer (Dry Type) (Sheet 6 of 9)

NIT/P.O. REFERENCE :

Sl.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
B.	**In-Process Inspection**								
1)	**End Frame & Enclosure**								
	Dimensional, Check of Weld Quality. Galvanising, Surface Finish & Painting	Visual	-do-	Approved Drawings/Technical Spec./IS:13947	TC	2/3	-	1	TC
2)	**Coil Assembly**								
a)	No. of Turns	Visual	-do-	-do-	TC	2/3	-	1	TC
b)	Transposition	-do-	-do-	-do-	TC	2/3	-	1	TC
c)	Brazing	Mechanical	100%	Approved Drawings/Technical Spec.	TC	2/3	-	1	TC
d)	Inter-Turn/Inter –Disc Insulation	Electrical	-do-	-do-	TC	2/3	-	1	TC
e)	Continuity	-do-	-do-	-do-	TC	2/3	-	1	TC
f)	End Insulation	-do-	-do-	-do-	TC	2/3	-	1	TC
g)	Winding Resistance	-do-	-do-	-do-	TC	2/3	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.30 Excitation Transformer (Dry Type) (Sheet 7 of 9)

NIT/P.O. REFERENCE :

Sl.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
h)	Coil Clamping Pressure	Measurement	-do-	Approved Drawings/Technical Spec.	TC	2/3	-	1	TC
2)	**Cast Resin Coils**								
a)	Dimension	Measurement	100%	Approved Drawings/Technical Spec./IEC:726	TC	2/3	-	1	TC
b)	IR for LV &HV	Electrical	-do-	-do-	TC	2/3	-	1	TC
c)	Resistance Test on HV & LV	-do-	-do-	-do-	TC	2/3	-	1	TC
d)	Capacitance before & after Clamping.	-do-	-do-	-do-	TC	2/3	-	1	TC
e)	Voltage Ratio, Voltage Vector Relationship.	-do-	-do-	-do-	TC	2/3	-	1	TC
3)	**Assemble**								
a)	Dimensional Check on Core	Measurement	-do-	-do-	TC	2/3	-	1	TC
b)	Core Assembly & Connections.	Visual	-do-	-do-	TC	2/3	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.30 Excitation Transformer (Dry Type) (Sheet 8 of 9)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
c)	Lead Position.	Visual	100%	Approved Drawings/Technical Spec./IEC:726	TC	2/3	-	1	TC
d)	HV Test between Core & Yoke Bolts.	Electrical	-do-	-do-	TC	2/3	-	1	TC
e)	Magnetic Unbalance	-do-	-do-	CBIP Manual	TC	2/3	-	1	TC
f)	Clearances & Creepage Measurement	Measurement	-do-	Approved Drawings/Technical Spec.	TC	2/3	-	1	TC
C.	**Final Inspection**								
1)	**Routine Tests**								
a)	Measurement of Winding Resistance.	Electrical	100%	Technical Spec./IS:11171 & IEC:726 & 76	JIR	2/3	1	-	CHP
b)	Measurement of Voltage Ratio/Check of Polarity/ Vector Relationship (Phase Displacement)	-do-	-do-	-do-	JIR	2/3	1	-	CHP
c)	Measurement of Short Circuit Impedance & Load Loss	-do-	-do-	-do-	JIR	2/3	1	-	CHP

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.30 Excitation Transformer (Dry Type) (Sheet 9 of 9)

Sl.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
d)	Measurement of No Load Losses	Electrical	100%	Technical Spec./IS:11171 & IEC:726 & 76	JIR	2/3	1	-	CHP
e)	Measurement of Magnetizing Current (before and after Dielectric Test)	-do-	-do-	-do-	JIR	2/3	1	-	CHP
f)	Measurement Insulation Resistance And Polarization Index	-do-	-do-	-do-	JIR	2/3	1	-	CHP
g)	Dielectric Test								
i)	Separated Source Voltage Withstand Test	Electrical	100%	-do-	JIR	2/3	1	-	CHP
ii)	Induced Overvoltage Withstand Test.	-do-	-do-	-do-	JIR	2/3	1	-	CHP
h)	Checks of Completeness of Transformer with Accessories	-do-	-do-	-do-	JIR	2/3	1	-	CHP

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

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(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.31 **Unit Control System** (Sheet 1 of 4)

Sl.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
A.	**Bought Out/ Manufactured Items**								
1.	**Mobile Engineering Work-Station, Mobile Operator Work-Station, Server, Computers, etc.**								
a)	Performance Test Certificate from Manufacturer	Test	100%	Approved Drawing/Technical Spec/IEC Code	TC	3/2	-	1	TC
b)	Check of BOM	Visual	-do-	-do-	JIR	3/2	-	1	CHP
c)	Checking of Make, Type & Rating	-do-	-do	-do-	JIR	3/2	1	-	CHP
d)	General Visual Inspection	-do-	-do-	-do	JIR	3/2	1	-	CHP
e)	Electrical Safety Inspection	Electrical	-do-	-do-	JIR	3/2	1	-	CHP
f)	Inspection of Power Supply	-do-	-do	-do-	JIR	3/2	1	-	CHP
g)	Functional Test	Test	-do-	-do-	JIR	3/2	1	-	CHP
2.	**UPS**								
a)	Make & Rating	Visual	-do-	-do-	JIR	3/2	1	-	CHP
b)	Capacity Test	Electrical	-do-	-do-	JIR	3/2	1	-	CHP

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.31 Unit Control System (Sheet 2 of 4)

NIT/P.O. REFERENCE :

Sl.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
c)	Functional Check (Protection)	Electrical	100%	Approved Drawing/Technical Spec/IEC Code	JIR	3/2	1	-	CHP
d)	Battery (Make & Rating)	Visual	-do-	-do-	JIR	3/2	1	-	CHP
e)	Voltage Check-up of UPS								
i)	Line to Neutral	Electrical	-do	-do-	JIR	3/2	1	-	CHP
ii)	Line to Ground	Electrical	-do-	-do	JIR	3/2	1	-	CHP
iii)	Neutral to Ground	Electrical	-do-	-do-	JIR	3/2	1	-	CHP
iv)	Load Back-up Test	Electrical	-do	-do-	JIR	3/2	1	-	CHP
3.	**Key Boards**								
a)	Performance Test Certificate from Manufacturer	Test	-do-	-do-	TC	3/2	-	1	TC
b)	Checking of Make, Type & Rating	Visual	-do-	-do-	JIR	3/2	1	-	CHP
c)	General Visual Inspection	-do-	-do-	-do-	JIR	3/2	1	-	CHP
d)	Functional Test	Test	-do-	-do-	JIR	3/2	1	-	CHP
4.	Optical Fibre Cable Routine Tests	Visual	-do-	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.31 Unit Control System (Sheet 3 of 4)

NIT/P.O. REFERENCE :

Sl.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
B	**Final Inspection**								
1.	**Unit Control Boards and Local Control Cubicles (LCC) with all accessories for units and its auxiliaries as per specifications.**			Approved Drawing/Technical Spec/IEC Code					
a)	Check for BOM and Layout	Visual	100%	-do-	JIR	3/2	1	-	CHP
b)	System Testing								
i)	Power Supplies Testing and verification of tolerance limit	Electrical	-do-	-do-	JIR	3/2	1	-	CHP
ii)	I/O Verification Tests	Electrical	-do-	-do-	JIR	3/2	1	-	CHP
iii)	Communication protocol compatibility with IEC 61850/IEC 60870-5-104	Electrical	-do	-do-	JIR	3/2	1	-	CHP
iv)	Ethernet and Serial communications testing and verification	Electrical	-do-	-do-	JIR	3/2	1	-	CHP
c)	Regulatory Tests								
i)	Dielectric Strength	Electrical	-do-	-do-	JIR	3/2	1	-	CHP
ii)	Ground Leakage	Electrical	-do-	-do-	JIR	3/2	1	-	CHP
d)	Hardware Acceptance Testing (Programmable Controller, Interfacing Equipment, RTU Equipment, Data Storage System, Routers, etc.)	Test	-do-	-do-	TC J	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.31 Unit Control System (Sheet 4 of 4)

NIT/P.O. REFERENCE :

Sl.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
e)	Software Acceptance Testing	Test	100%	Approved Drawing/Technical Spec/IEC Code	TC	3/1	-	1	TC
f)	Factory Acceptance Test (Integrated Acceptance Testing/System checking) as per Acceptance Test Plan	Electrical	-do-	-do-	JIR	3/2	1	-	CHP
2.	**Training Simulators**	Functional	-do-	-do-	JIR	3/2	1	-	CHP
3.	**Time Synchronization with the Universal Time Synchronization system via Station LAN**	Functional	-do	-do-	JIR	3/2	1	-	CHP
4.	**Emergency Shutdown System (for each unit and for entire Station)**	Functional	-do-	-do	JIR	3/2	1	-	CHP
5.	**Ethernet Switches**								
a)	Make, Type and Rating	Visual	-do-	-do-	JIR	3/2	1	-	CHP
b)	Functional Checks	Tests	-do	-do-	JIR	3/2	1	-	CHP
c)	Factory Acceptance test	Test	-do-	-do-	JIR	3/2	1	-	CHP

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.32 **Main Inlet Valve** (Sheet 1 of 6)

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
1.	**Raw Material & Bought Out Items**								
1.1	Valve Body								
a)	Chemical Analysis	Chemical	Sample	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
b)	Mechanical Properties	Mechanical	Sample	-do-	TC	3/2	-	1	TC
c)	NDT of Cast Steel	UT	100%	-do-	TC	3/2	-	1	TC
1.2	Valve Rotor/Plug, Trunnions and Bearing Sleeve								
a)	Chemical Analysis	Chemical	Sample	-do-	TC	3/2	-	1	TC
b)	Mechanical Properties	Mechanical	Sample	-do-	TC	3/2	-	1	TC
c)	NDT of Cast/ Forged steel	UT	100%	-do-	TC	3/2	-	1	TC
1.3	Downstream Dismantling Section and Upstream & Downstream Sleeve								
a)	Chemical Analysis	Chemical	Sample	-do-	TC	3/2	-	1	TC
b)	Mechanical Properties	Mechanical	Sample	-do-	TC	3/2	-	1	TC
1.4	Valve Seal & Seat, Mobile Ring and Seal carrier Ring								
a)	Chemical Analysis	Chemical	Sample	-do-	TC	3/2	-	1	TC
b)	Mechanical Properties	Mechanical	Sample	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.
c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

Khorlochhu Hydro Power Ltd.

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.32 Main Inlet Valve (Sheet 2 of 6)

NIT/P.O. REFERENCE :

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
1.5	Lubricating Oil, Grease & Water Pipe Line								
a)	Chemical Analysis	Chemical	Sample	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	1	-	CHP
b)	Mechanical Properties	Mechanical	Sample	-do-	TC	3/2	-	1	TC
c)	Dimensional Check	Measurement	100%	-do-	IR	3/2	-	1	RR
d)	Hydro-static Pressure Test	Test	100%	-do-	TC	3/2	-	1	TC
1.6	Filler Metal for Overlay								
a)	Chemical Analysis	Chemical	Sample	-do-	TC	3/2	-	1	TC
b)	Mechanical Properties	Mechanical	Sample	-do-	TC	3/2	-	1	TC
1.7	Lever, Key, Fastener & Counter Weight								
a)	Chemical Analysis	Chemical	Sample	-do-	TC	3/2	-	1	TC
b)	Mechanical Properties	Mechanical	Sample	-do-	TC	3/2	-	1	TC
1.8	Air Bleeding Valve, Guard Valve, Blow Off Valve & Air Relief Valve etc.								
a)	Hydro-static Pressure Test	Test	Sample	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.32 Main Inlet Valve(Sheet 3 of 6)

NIT/P.O. REFERENCE :

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
1.9	Inlet & Out let Pipes								
a)	Chemical Analysis	Chemical	Sample	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
b)	Mechanical Properties	Mechanical	Sample	-do-	TC	3/2	-	1	TC
c)	NDT of Weld Joints	DPT/MPI/UT/RT (as applicable)	100%	-do-	TC	3/2	-	1	TC
d)	Dimensional Check	Measurement	100%	-do-	IR	3/2	-	1	RR
e)	Hydro-static Pressure Test	Test	100%	-do-	TC	3/2	-	1	TC
1.10	Rubber Cord			-					
a)	Material Properties	Test	sample	-do-	TC	3/2	-	1	TC
b)	Dimensional Check	Measurement	100%	-do-	IR	3/2	-	1	RR
2.	**In-Process Stage**								
2.1	Stress Relieving of valve Body & Rotor/Plug with Trunnion	Temperature Regulation	100%	-do-	IR	3/2	-	1	IR
2.2	NDT of all weld joints before & after stress relieving.	DPT/MPI & UT (as applicable)	100%	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.32 Main Inlet Valve (Sheet 4 of 6)

NIT/P.O. REFERENCE :

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
2.3	Dimensional Check after Machining	Measurement	100%	Approved Drawings/Technical Spec./Relevant Standard	IR	3/2	-	1	RR
2.4	Dimensional Check of Individual Components of Spherical Valve i.e. Plug, Trunnion, Upstream & Downstream Body, Mobile Ring, Seal & Seal Carrier Ring and Lever etc. before Assembly	Measurement	100%	-do-	TC	3/2	-	1	TC
2.5	Surface Finish of Machined surface	Visual/Measurement	100%	-do-	TC	3/2	-	1	TC
2.6	NDT of Overlay Finished Surface and Contact Surface of Mobile Ring & Seat	DPT/MPI	100%	-do-	TC	3/2	-	1	TC
3.	**Final Inspection**								
3.1	Shop Assembly and Testing of Spherical Valve								
a)	Hydro-Static Pressure Test of complete Assembly of Spherical Valve Body & Rotor / Plug with Valve Extensions on both ends	Pressure Test	100%	-do-	JIR	3/2	1	-	CHP
b)	Leakage Test on Upstream & Downstream valve seals	Test	100%	-do-	JIR	3/2	1	-	CHP

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.32 Main Inlet Valve (Sheet 5 of 6)

NIT/P.O. REFERENCE :

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
c)	Assembly & Operational Test for free movement of Plug & Seals with Servomotor	Visual/Measurement	100%	Approved Drawings/Technical Spec./Relevant Standard	JIR	3/2	1	-	CHP
d)	Stroke length of Upstream & Downstream Mobile Ring	Measurement	100%	-do-	JIR	3/2	1	-	CHP
3.2	Bypass Valve								
a)	Hydro-Static Pressure Test	Pressure Test	100%	-do-	JIR	3/2	1	-	CHP
b)	Leakage Test	Test	100%	-do-	JIR	3/2	1	-	CHP
c)	Dimensional Check	Measurement	100%	-do-	JIR	3/2	1	-	CHP
d)	Operational Test	Test	100%	-do-	JIR	3/2	1	-	CHP
3.3	Air Release & Drain Valve etc.								
a)	Hydro-Static Pressure Test	Pressure Test	100%	-do-	JIR	3/2	1	-	CHP
b)	Leakage Test	Test	100%	-do-	JIR	3/2	1	-	CHP
c)	Dimensional Check	Measurement	100%	-do-	JIR	3/2	1	-	CHP
d)	Operational Test	Test	100%	-do-	JIR	3/2	1	-	CHP

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.32 Main Inlet Valve(Sheet 6 of 6)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
3.4	Control Panel								
a)	Verification of Bill of Material	Visual	100%	Approved Drawings/Technical Spec./Relevant Standard	JIR	3/2	1	-	CHP
b)	Functional Test	Test	100%	-do-	JIR	3/2	1	-	CHP
c)	IR & HV Test	Test	100%	-do-	JIR	3/2	1	-	CHP
3.5	Painting & Preservation	Visual & Measurement	10% Random	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.33 Servo for Main Inlet Valve

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
1.	**Raw Material**								
1.1	Piston & Cylinder								
a)	Chemical Analysis	Chemical	Sample	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
b)	Mechanical Properties	Mechanical	Sample	-do-	TC	3/2	-	1	TC
c)	NDT of Plate/Casting Material	UT/MPI	100%	-do-	TC	3/2	-	1	TC
2.	**In-process Inspection**								
2.1	Heat Treatment of Piston & Cylinder	Temperature Regulation	100%	-do-	IR	3/2	-	1	RR
2.2	NDT of weld joints before & after Heat Treatment	Radiography/UT/DPT	100%	-do-	TC	3/2	-	1	TC
2.3	Dimensional checks after machining	Measurement	100%	-do-	IR	3/2	-	1	RR
3.	**Final Inspection**								
3.1	Dimensional check	Measurement	100%	-do-	JIR	3/2	1	-	CHP
3.2	Stroke Length	Measurement	100%	-do-	JIR	3/2	1	-	CHP
3.3	Functional Test of Servomotor	Test	100%	-do-	JIR	3/2	1	-	CHP
3.4	Hydraulic Pressure Test of Servomotor	Test	100%	-do-	JIR	3/2	1	-	CHP
3.5	Leakage Test	Test	100%	-do-	JIR	3/2	1	-	CHP
3.6	Painting & Preservation	Visual & Measurement	10% Random	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.34 **Electric Overhead Travel (EOT) Crane** (Sheet 1 of 5)

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/ Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
1.	**Raw Material**								
1.1	Structural Steel (Box Girder, End Trucks, Trolly, Rails etc.)	• Chemical analysis • Mechanical Properties • Ultrasonic Test	• Sample/Batch • Sample/Batch • 100%	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
1.2	Cast/Forged Steel (Wheels, Shafts, Pins, Gears, Pinions, Brake Drum, Couplings, Hook etc.)	• Chemical analysis • Mechanical Properties • Ultrasonic Test	• Sample/Batch • Sample/Batch • 100%	-do-	TC	3/2	-	1	TC
1.3	Bought Out Items -								
a)	Bushes, Bearings, Pulleys, Fasteners etc.	Mechanical Properties	Sample/Batch	-do-	TC	3/2	-	1	
b)	Drive Motor, Gear Box, Plummer Block, EHT Brakes, EM Brakes, Wire Rope, Electrical Cables	Routine Test	100%	-do-	TC	3/2	-	1	TC
2.	**In-Process - Fabrication**								
2.1	NDT-Welding Fillet Welds	MPI/DPT	100%	-do-	TC	3/2	-	1	TC
2.2	NDT-Butt Welds (Box Girder, Rope Drums and other full strength welds)	X-Ray/UT	100%	-do-	TC	3/2	-	1	
2.3	Post Weld Heat Treatment (Fabricated Rope Drums, Gear Box Housing, Forged Crane hooks)	Heat Treatment	100%	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.34 Electric Overhead Travel (EOT) Crane(Sheet 2 of 5)

NIT/P.O. REFERENCE :

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
2.4	Machining								
a)	Surface Finish (Rope drum shaft, Rope Drum grooves, Brake Drum)	Visual / Measurement	100%	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
b)	Dimensions	Measurement	100%	-do-	IR	3/2	-	1	RR
2.5	Sub-Assembly Stage – Drive Mechanism, Hoist / Trolly arrangements, Brakes								
a)	Alignment/Layout	Visual / Measurement	100%	-do-	IR	3/2	-	1	RR
b)	Fitment and Clearance	Visual / Measurement	100%	-do-	IR	3/2	-	1	RR
c)	Dimensional check	Visual / Measurement	100%	-do-	IR	3/2	-	1	RR
d)	Running Performance (Drive Motors, Gear Boxes)-Noise level, Vibration, Temperature rise Leakage Test - Gear	Visual / Measurement	100%	-do-	TC	3/2	-	1	TC
e)	Crane Hook-Proof Load Test	Load Test	100%	-do-	TC	3/2	-	1	TC
f)	NDT-after Proof Load Test Butt Welds (Box Girder, Rope Drums and other full strength Welds)	DPT/MPI	100%	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.34 Electric Overhead Travel (EOT) Crane (Sheet 3 of 5)

NIT/P.O. REFERENCE :

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
3.	**Final Inspection / Tests on assembled Crane at manufacturer's works:-**								
3.1	Examination of Welding	Visual	100%	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
a)	Welding- NDT	DPT	10%	-do-	TC	3/2	-	1	TC
3.2	Dimensional check on assembled crane - bridge structure (Box girders, end trucks) hoisting trolly frame, travelling mechanism	Measurement	100%	Approved Drawings/Technical Spec./Relevant standard/ Inspection Protocol	TC	3/2	-	1	TC
3.3	Crane Girder Camber	Measurement	100%	Approved Drawings/Technical Spec.	TC	3/2	-	1	TC
3.4	Deflection test at full load/ Rated load	Measurement	1/Type	Approved Drawings/Technical Spec./IS: 3177/IEC	JIR	3/2	1	-	CHP
4.	Operational/functional test with original control panels								
4.1	Hoisting and CT Speeds - without load	Measurement	1/Type	-do-	JIR	3/2	1	-	CHP
4.2	Hoisting and CT Speeds at Rated load	Measurement	1/Type	-do-	JIR	3/2	1	-	CHP

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.34 Electric Overhead Travel (EOT) Crane(Sheet 4 of 5)

NIT/P.O. REFERENCE :

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
4.3	Function of brakes for trolley and hoisting	Visual	1/Type	Approved Drawings/Technical Spec./IS: 3177/IEC	JIR	3/2	1	-	CHP
4.4	Amperage at no load and full load for all motors	Measurement	1/Type	-do-	JIR	3/2	1	-	CHP
4.5	Creeping speed/ Jog movement with rated load	Visual / Measurement	1/Type	-do-	JIR	3/2	1	-	CHP
4.6	Over Load Test at 125% of rated load	Visual / Measurement	1/Type	-do-	JIR	3/2	1	-	CHP
4.7	Sand blasting & Painting		1/Type	Painting Protocol/IS	TC	3/2	-	1	TC
4.8	Control Panel (at Supplier's Premises)								
a)	Resistors, Capacitors, Limit Switches, Master Controllers, Thyristers, VVVF Modules, Transformers, Circuit Breakers, Switches etc.	Electrical	100%	Approved Drawings/Technical Spec./IEC	TC	3/2	-	1	TC
b)	Verification of scheme, make and rating of components	Visual	1/Type	-do-	JIR	3/2	1	-	CHP
c)	Cubicle Dimensions	Measurement	1/Type	-do-	JIR	3/2	1	-	CHP
d)	Functional check including HV and IR Test	Electrical	1/Type	-do-	JIR	3/2	1	-	CHP
e)	Sequence of operation and interlock tests	Electrical	1/Type	-do-	JIR	3/2	1	-	CHP

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.34 Electric Overhead Travel (EOT) Crane (Sheet 5 of 5)

NIT/P.O. REFERENCE :

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
f)	Single phase protection	Electrical	1/Type	Approved Drawings/Technical Spec./IS: 3177/IEC	JIR	3/2	1	-	CHP
g)	Instantaneous over current protection	Electrical	1/Type	-do-	TC	3/2	-	1	TC
h)	Thermal overload relay	Electrical	1/Type	-do-	TC	3/2	-	1	TC
i)	Under Voltage Protection	Electrical	1/Type	-do-	TC	3/2	-	1	TC
4.9	Radio Control Tests of Speed Control of Bridge Travel, Trolly Travel & Hoist Motion, Control of Master Contactor, Indication and Alarm (if applicable)	Functional Test	1/Type	-do-	JIR	3/2	1	-	CHP
4.10	Pendant control test (if applicable)	Electrical	1/Type	-do-	JIR	3/2	1	-	CHP

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.35 **Butterfly Valve (BFV) and Accessories** (Sheet 1 of 5)

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/ Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
1.	**Raw Materials**								
1.1	**Butterfly Valve Body, Disc & Trunnion, Upstream & Downstream connection Pipe and Coupling Flanges**								
a)	Chemical Analysis	Chemical	Sample	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
b)	Mechanical Properties	Mechanical	-do-	-do-	TC	3/2	-	1	TC
c)	NDT of Cast/Wieldable Plate/Forged Steel	UT/RT	100%	-do-	TC	3/2	-	1	TC
d)	Heat Treatment	Temperature Regulation	100%	-do-	IR	3/2	-	1	TC
1.2	**Bush. Lever, Counter Weight**								
a)	Chemical Analysis	Chemical	Sample	-do-	TC	3/2	-	1	TC
b)	Mechanical Properties	Mechanical	-do-	-do-	TC	3/2	-	1	TC
c)	NDT of Cast/Weldable Plate/Forged Steel	UT/RT	100%	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

Khorlochhu Hydro Power Ltd.

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.35 Butterfly Valve (BFV) and Accessories (Sheet 2 of 5)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/ Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
1.3	**Seal Seat, Seal Retainer & Fastener**								
a)	Chemical Analysis	Chemical	Sample	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
b)	Mechanical Properties	Mechanical	-do-	-do-	TC	3/2	-	1	TC
1.4	**Seal**								
a)	Mechanical & Chemical Analysis	Test	Sample	-do-	TC	3/2	-	1	TC
b)	Hardness	Test	-do-	-do-					
c)	Dimensional Check	Measurement	100%	-do-	IR	3/2	-	1	RR
1.5	**By-Pass Valve**								
a)	Chemical Analysis	Chemical	Sample	-do-	TC	3/2	-	1	TC
b)	Mechanical Properties	Mechanical	-do-	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

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(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP **CLIENT :** KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.35 Butterfly Valve (BFV) and Accessories (Sheet 3 of 5) **NIT/P.O. REFERENCE :**

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
c)	NDT of Cast/Forged Steel	UT/RT	100%	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
d)	Heat Treatment	Temp. Regulation	100%	-do-	IR	3/2	-	1	RR
1.6	**Grease, Water & Oil Pipe Line**								
a)	Chemical Analysis	Chemical Analysis	Sample	-do-	TC	**3/2**	**-**	**1**	TC
b)	Mechanical Properties	Mechanical	Sample	-do-	TC	3/2	-	1	TC
c)	Dimensional Check	Measurement	100%	-do-	IR	3/2	-	1	RR
d)	Hydro-Static Pressure Test	Test	-do-	-do-	TC	3/2	-	1	TC
1.7	**Guard Valve, Air Admission & Release Valve & Drain Valve etc.**								
a)	Hydro-Static Pressure Test	Test	-do-	-do-	TC	3/2	-	1	TC
2.	**In-Process Inspection**								

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.35 Butterfly Valve (BFV) and Accessories (Sheet 4 of 5)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
a)	NDT of Weld Joints before Stress Relieving	MPI/DPT /UT/RT(As Applicable)	100%	Approved Drawings/Technical Spec./Relevant Standard	IR	3/2	-	1	RR
b)	Valve Body & Disc- Stress Relieving after Welding	Temperature Regulation	-do-	-do-		3/2	-	1	RR
c)	NDT of all Weld Joints after Stress Relieving	MPI/DPT & UT/RT (As Applicable	-do-	-do-	TC	3/2	-	1	TC
d)	Dim. Check & Surface Finish of Machined Surface for Body, Disc, Journal, Seal & Seal Seat	Measurement	100%		IR	3/2	-	1	RR
3.	**Final Inspection**								
3.1	**Assemble of Butterfly Valve with Servomotor etc.**								
a)	Dimensional Check & Surface Finish of Complete Assembly	Measurement	Critical dim.	-do-	JIR	3/2	1	-	CHP
b)	Operational Test- Free Movement of Disc with Servomotor	Visual &Measurement	100%	Approved Drawings/Technical Spec./IS:7326	JIR	3/2	1	-	CHP
c)	Hydro-Static Test on Butterfly Valve Body & Disc With Upstream & Downstream Pipes	-do-	-do-	-do-	JIR	3/2	1	-	CHP
d)	Leakage Test on Valve Seals	-do-	-do-	-do-	JIR	3/2	1	-	CHP

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.35 Butterfly Valve (BFV) and Accessories (Sheet 5 of 5)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
3.2	**By Pass Valve**								
a)	Hydro-Static Pressure Test	Pressure Test	100%	Apprd./Drg.Tech.Spec./Relevant Standard	JIR	3/2	1	-	CHP
b)	Leakage Test	Test	-do-	-do-	JIR	3/2	1	-	CHP
c)	Operational Test	Test	-do-	-do-	JIR	3/2	1	-	CHP
3.3	**Drain Valve, Air Release Valve etc.**								
a)	Hydro-Static Pressure Test	Pressure Test	-do-	-do-	JIR	3/2	1	-	CHP
b)	Leakage Test	Test	-do-	-do-	JIR	3/2	1	-	CHP
c)	Operational Test	Test	-do-	-do-	JIR	3/2	1	-	CHP
3.4	**Painting & Preservation**	Visual/ Measurement	-do-	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
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Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.36 **Servomotor for Butterfly Valve (BFV)** (Sheet 1 of 2)

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
1.	**Raw Materials**								
1.1	**Piston & Cylinder**								
a)	Chemical Analysis	Chemical	Sample	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	**1**	TC
b)	Mechanical Properties	Mechanical	-do-	-do-	TC	3/2	-	1	TC
c)	NDT of Cast/Weld able Steel	UT/MPI	100%	-do-	TC	3/2	-	1	TC
2.	**In-Process Inspection**								
a)	Heat Treatment of Piston & Cylinder	Temp.Regulation	-do-	-do-	IR	3/2	-	1	RR
b)	NDT of Weld Joints before & after Heat Treatment	Radiography/UT/DPT	-do-	-do-	TC	3/2	-	1	TC
c)	Dimensional Examination after Machining	Measurement	-do-	-do-	IR	3/2	-	1	RR
3.	**Final Inspection**								

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.36 Servomotor for Butterfly Valve(BFV) (Sheet 2 of 2)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
a)	Dimensional Check	Measurement	-do-	Approved Drawings/Technical Spec./Relevant Standard	JIR	3/2	1	-	CHP
b)	Stroke Length	-do-	-do-	-do-	JIR	3/2	1	-	CHP
c)	Functional Test of Servo-Motor	-do-	-do-	-do-	JIR	3/2	1	-	CHP
d)	Hydraulic Pressure Test of Servomotor	Test	-do-	-do-	JIR	3/2	1	-	CHP
e)	Leakage Test	Test	-do-	-do-	JIR	3/2	1	-	CHP
f)	Painting & Preservation	Visual & Measurement	10% at Random	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.37 **Oil Pressure Unit (OPU)** (Sheet 1 of 5)

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
1.	**Sump Tank**								
a)	Material of Tank								
i)	Chemical Composition	Chemical	Sample	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
ii)	Mechanical Strength	Mechanical	-do-	-do-	TC	3/2	-	1	TC
b)	NDT of Weld Joints	UT/DPT	100%	-do-	TC	3/2	-	1	TC
c)	No Leak Test for Tank	Test	-do-	-do-	TC	3/2	-	1	TC
d)	Dimensional Check	Measurement	-do-	-do-	TC	3/2	-	1	TC
2.	**Pressure Vessel**								
a)	Material of Tank								
i)	Chemical Composition	Chemical	Sample	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
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Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.37 Oil Pressure Unit (OPU) (Sheet 2 of 5)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
ii)	Mechanical Strength	Mechanical	Sample	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
b)	NDT of Weld Joints	UT/DPT	100%	-do-	TC	3/2	-	1	TC
c)	Post Weld Stress Relieving	Temperature Regulation	100%	-do-	TC	3/2	-	1	TC
d)	Hydrostatic Pressure Test For Pressure Vessel	Test	100%	-do-	TC	3/2	-	1	TC
e)	Dimensional Check	Measurement	100%	-do-	TC	3/2	-	1	TC
3.	**Pipes & Fittings**								
a)	Chemical Composition	Chemical	Sample	-do-	TC	3/2	-	1	TC
b)	Mechanical Strength	Mechanical	-do-	-do-	TC	3/2	-	1	TC
c)	Hydro Static Pressure Test	Test	100%	-do-	TC	3/2	-	1	TC
d)	Dimensional Check	Measurement	100%	-do-	IR	3/2	-	1	RR

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.37 Oil Pressure Unit (OPU) (Sheet 3 of 5)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
4.	**Pressure Gauge, Pressure Switch, Float Switch, Temperature Switch etc.**								
a)	Make, Model &Type	Visual	100%	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
b)	Calibration Test	Test	-do-	-do-	TC	3/2	-	1	TC
c)	Functional Test	Test	-do-	-do-	TC	3/2	-	1	TC
5.	**Unloader Valve, Check Valve, Pilot Valve, Safety Valve, Air Blow Off Valve, By Pass Valve, Solenoid Valve and Isolating Valve etc.**								
a)	Make, Model &Type	Visual	-do-	-do-	TC	3/2	-	1	TC
b)	Functional Check	Test	-do-	-do-	TC	3/2	-	1	TC
c)	Hydro Static Pressure Test	Test	-do-	-do-	TC	3/2	-	1	TC
6.	**Oil Pump**								
a)	Make, Model, Type & Capacity	Visual	-do-	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

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(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.37 Oil Pressure Unit (OPU) (Sheet 4 of 5)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
b)	Routine Test	Test	100%	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
7.	**Electric Motor**								
a)	Make, Type & Rating	Visual	-do-	-do-	TC	3/2	-	1	TC
b)	Routine Test	Test	-do-	-do-	TC	3/2	-	1	TC
8.	**Strainer**								
a)	Mesh Size	Measurement	-do-	-do-	TC	3/2	-	1	TC
b)	Chemical Composition	Chemical	Sample	-do-	TC	3/2	-	1	TC
9.	**Oil**								
a)	Make & Type	Visual	-do-	-do-	TC	3/2	-	1	TC
10.	**Complete Assemble of Oil Pressure Unit with Control Panel**								

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

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(Vendor)

Khorlochhu Hydro Power Ltd.

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.37 Oil Pressure Unit (OPU) (Sheet 5 of 5)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
a)	Dimensional Check	Measurement	100%	Approved Drawings/Technical Spec./Relevant Standard	JIR	3/2	1	-	CHP
b)	Capacity	Measurement	-do-	-do-	JIR	3/2	1	-	CHP
c)	Functional Test/Operational Test of Pumps, Motors, Electromagnetic Valves, Pressure Switch & Accessories.	Test	-do-	-do-	JIR	3/2	1	-	CHP
d)	Pressure Tank Relief Valve Setting	Visual	-do-	-do-	JIR	3/2	1	-	CHP
11.	**Control Panel**				JIR	3/2	1	-	CHP
a)	Verification of Bill of Material	Visual	-do-	-do-	JIR	3/2	1	-	CHP
b)	Functional Test	Test	-do-	-do-	JIR	3/2	1	-	CHP
c)	IR &HV Test	Test	-do-	-do-	JIR	3/2	1	-	CHP
12.	**Painting & Preservation**	Visual &Measurement	100%	-do-	TC	3/2	1	-	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

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QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.38 **Oil Leakage Unit** (Sheet 1 of 2)

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
1.	**Leakage Oil Unit(if required)**								
1.1	**Pump**								
a)	Make, Model, Type & Capacity	Visual	100%	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
b)	Routine Test	Test	100%	-do-	TC	3/2	-	1	TC
1.2	**Motor**								
a)	Make, Model & Rating	Visual	100%	-do-	TC	3/2	-	1	TC
b)	Routine Test	Test	100%	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

Khorlochhu Hydro Power Ltd.

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.38 Oil Leakage Unit (Sheet 2 of 2)

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
1.3	**Float Switch**								
a)	Make, Model & Rating	Visual	100%	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
1.4	**Oil Tank**								
a)	Leakage Test	Test	100%	-do-	TC	3/2	-	1	TC
b)	Dimensional Check	Measurement	100%	-do-	TC	3/2	-	1	TC
1.5	**Functional Test on Complete Oil Leakage Unit**	Test	100%	-do-	TC	3/2	-	1	TC
1.6	**Dimensional & BOM Check**	Visual &Measurement	100%	-do-	TC	3/2	-	1	TC
1.7	**Painting & Preservation**	Visual &Measurement	100%	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.39 **Lubricating Oil System** (Sheet 1 of 6)

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
1.	**Centrifuge**								
1.1	Centrifugal Oil Purifier – Bowl Body, Hood & Lock Ring	Chemical	Sample/Batch	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
a)	Chemical Composition	Mechanical	Sample/Batch	-do-	TC	3/2	-	1	TC
b)	Mechanical Strength	Measurement	100%	-do-	TC	3/2	-	1	TC
1.2	**In Process Control**			-do-	TC	3/2	-	1	TC
a)	Bowl Assembly: Dynamic Balancing	Measurement	100%	-do-	TC	3/2	-	1	TC
b)	Bearing Assembly, Idler Arm Assembly, Idler Bearing Assembly, Drag Assembly: Smoothness/ Freeness of Rotation	Visual	100%	-do-	TC	3/2	-	1	TC
2.	**Bearings**								
a)	Type, make & Rating	Visual	100%	-do-	TC	3/2	-	1	TC
3.	**Valves, Pipes, Fitting & Hoses etc.**								
a)	Chemical Composition	Chemical	Sample/Batch	Approved Drawings/Technical Spec./Relevant Standard/IS: 5290, IS: 1239	TC	3/2	-	1	TC
b)	Mechanical Strength	Mechanical	Sample/Batch	-do-	TC	3/2	-	1	TC
c)	Dimensional Check	Measurement	100%	-do-	IR	3/2	-	1	RR

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.39 Lubricating Oil Purifier System (Sheet 2 of 6)

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
d)	Pressure Test	Test	100%	Approved Drawings/Technical Spec./Relevant Standard/IS: 5290, IS: 1239	TC	3/2	-	1	TC
e)	HV & IR Test for Solenoid Valve	Electrical	100%	-do-	TC	3/2	-	1	TC
4.	**Temperature Gauge, Flow Meter, Pressure Gauge, Level switch, Solenoid Valve, Thermostat etc.**								
a)	Type, make & Rating	Visual	1 Lot	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
b)	HV & IR Test	Electrical Test	100%	-do-	TC	3/2	-	1	TC
c)	Performance, Accuracy, Repeatability & Calibration (as applicable)	Performance Test	100%	-do-	TC	3/2	-	1	TC
5.	**Circulating Pump(Gear Type)**								
a)	Type, Make & Capacity	Visual	100%	-do-	TC	3/2	-	1	TC
b)	Physical & Chemical properties	Test	1 Heat	-do-	TC	3/2	-	1	TC
c)	Leak Tightness of Casing	Leak Test	100%	-do-	TC	3/2	-	1	TC
d)	Performance Test								
i)	Q v/s Head, Q v/s Power & Q v/s Pump efficiency	Type Test	1 Type	-do-	TC	3/2	-	1	TC
ii)	NPSH (Net Positive Suction Head)Test	Type Test	1 Type	-do-	TC	3/2	-	1	TC
iii)	Leakage Test	Type Test	1 Type	-do-	TC	3/2	-	1	TC

Note:

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Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

Khorlochhu Hydro Power Ltd.

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.39 Lubricating Oil Purifier System(Sheet 3 of 6)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
iv)	Bearing Temperature Rise Test	Type Test	1 Type	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
v)	Vibration & Noise	Type Test	1 Type	-do-	TC	3/2	-	1	TC
e)	Painting Inspection (Uniformity, Shade, Adhesion & DFT)	Visual & Measurement	100%	-do-	TC	3/2	-	1	TC
6.	**Vacuum Pump (Rotary Vane)**								
a)	Type, Make & Capacity	Visual	100%	-do-	TC	3/2	-	1	TC
b)	Physical. & Chemical properties	Test	1 Heat	-do-	TC	3/2	-	1	TC
c)	Leak Tightness of Casing	Leak test	100%	-do-	TC	3/2	-	1	TC
d)	Performance Test								
i)	Bearing Temp. Rise Test	Type Test	1 Type	-do-	TC	3/2	-	1	TC
ii)	Free air Displacement	Type Test	1 Type	-do-	TC	3/2	-	1	TC
iii)	Ultimate Vacuum pulled by the Pump	Type Test	1 Type	-do-	TC	3/2	-	1	TC
e)	Painting Inspection (Uniformity, Shade, Adhesion & DFT)	Visual & Measurement	100%	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

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Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.39 Lubricating Oil Purifier System (Sheet 4 of 6)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
7.	**Motors**								
a)	Make & Rating	Visual	100%	Approved Drawings/Technical Spec./IS: 325	TC	3/2	-	1	TC
b)	Type Test	Test	Sample	-do-	TC	3/2	-	1	TC
c)	Routine Test	Test	100%	-do-	TC	3/2	-	1	TC
8.	**Filters/Strainers**								
a)	Type, Make & Rating	Visual	100%	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
b)	Physical & Chemical properties	Test	1 Heat	-do-	TC	3/2	-	1	TC
c)	Mesh Size	Measurement	100%	-do-	TC	3/2	-	1	TC
d)	Hydrostatic Test	Test	100%	-do-	TC	3/2	-	1	TC
e)	Performance Test	Test	100%	-do-	TC	3/2	-	1	TC
f)	Painting Inspection (Uniformity, Shade, Adhesion & DFT)	Visual & Measurement	100%	-do-	TC	3/2	-	1	TC
9.	**Direct Type Electric Oil Heater & Degassing Chamber**								
a)	Type, Make & Rating	Visual	100%	-do-	TC	3/2	-	1	TC
b)	Leak Tightness Test	Leak Test	100%	-do-	TC	3/2	-	1	TC
c)	IR Test for Heater	Electrical Test	100%	-do-	TC	3/2	-	1	TC

Note:

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b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

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Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.39 Lubricating Oil Purifier System (Sheet 5 of 6)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
10.	**Vacuum & Oil Tank**								
a)	Chemical Composition	Visual	Sample/Lot	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
b)	Mechanical Strength	Mechanical	Sample/Lot	-do-	TC	3/2	-	1	TC
c)	Capacity	Measurement	100%	-do-	IR	3/2	-	1	RR
d)	Leakage Test	Test	100%	-do-	TC	3/2	-	1	TC
	FINAL INSPECTION:-								
1.	**Purification Test of Lubricating Oil (Single Pass)**								
a)	Moisture Content (PPM)	Measurement	100%	Approved Drawings/Technical Spec./IS: 1012	JIR	3/2	1	-	CHP
b)	Suspended Particle	Test	100%	-do-	JIR	3/2	1	-	CHP
2.	**Lubricating Oil Purifier System including Control Panel**								
a)	Dimension Check of Assembly	Measurement	100%	Approved Drawings/Technical Spec./Relevant Standard	JIR	3/2	1	-	CHP
b)	Verification of Bill of Material	Visual	100%	-do-	JIR	3/2	1	-	CHP
c)	Capacity (Suction & discharge	Measurement	100%	-do-	JIR	3/2	1	-	CHP

Note:

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b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

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QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.39 Lubricating Oil Purifier System (Sheet 6 of 6)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
d)	Power Consumption Test for Motors & Heaters	Electrical	100%	Approved Drawings/Technical Spec./Relevant Standard	JIR	3/2	1	-	CHP
e)	Sequential Operation & Interlock Vacuum Test at 650 mm of Hg	Functional	100%	-do-	JIR	3/2	1	-	CHP
f)	Vacuum Test at 650 mm of Hg	Leak test	100%	-do-	JIR	3/2	1	-	CHP
g)	Vibration & Noise Measurement	Measurement	100%	-do-	JIR	3/2	1	-	CHP
h)	Tests on Control Panel		100%	-do-	JIR	3/2	1	-	CHP
i)	Dimension Check	Measurement	100%	-do-	JIR	3/2	1	-	CHP
ii)	HV & IR Test	Electrical	100%	-do-	JIR	3/2	1	-	CHP
iii)	Wiring, Interlock & Sequence Check	Electrical	100%	-do-	JIR	3/2	1	-	CHP
iv)	Painting Inspection (Uniformity, Shade, Adhesion & DFT)	Visual & Measurement	100%	-do-	JIR	3/2	1	-	CHP
v)	Degree of Protection	Test	100%	Approved Drawings/Technical Spec./IS: 13947	JIR	3/2	1	-	CHP

Note:

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QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.40 **Cooling Water System** (Sheet 1 of 6)

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
1.	**Motorized Valve**								
i)	Make, Type & Rating	Visual	100%	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
ii)	Functional Check	Visual	100%	-do-	TC	3/2	-	1	TC
2.	**Line Filter**								
a)	Mesh Size	Measurement	100%	-do-	TC	3/2	-	1	TC
3.	**Automatic Self-Flushing Filter**								
a)	Chemical composition	Chemical	Sample	-do-	TC	3/2	-	1	TC
b)	Mechanical Properties	Mechanical	Sample	-do-	TC	3/2	-	1	TC
c)	Pressure Test	Test	100%	-do-	TC	3/2	-	1	TC
d)	Functional Check	Visual	100%	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.40 Cooling Water System (Sheet 2 of 6)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
4.	**Cyclone Separator**								
a)	**Casing**								
i)	Chemical Composition	Chemical	Sample	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
ii)	Mechanical Properties	Mechanical/Visual	Sample	-do-	TC	3/2	-	1	TC
b)	Functional check of complete Assembly	Measurement	100%	-do-	TC	3/2	-	1	TC
5.	**Electro Magnetic Water Flow Switch & Flow Meter cum Switches**	Chemical	Sample	-do-	TC	3/2	-	1	TC
a)	Make, Type & Rating	Visual	100%	-do-	TC	3/2	-	1	TC
b)	Functional Check	Visual	100%	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

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QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.40 Cooling Water System (Sheet 3 of 6)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
6.	**Black Washing Multimedia Filters**								
a)	Chemical Composition	Chemical	Sample	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
b)	Mechanical Properties	Mechanical	Sample	-do-	TC	3/2	-	1	TC
c)	Pressure Test	Test	100%	-do-	TC	3/2	-	1	TC
d)	Functional Check	Visual	100%	-do-	TC	3/2	-	1	TC
7.	**Pump**								
a)	Make, Type & Rating	Visual	100%	-do-	TC	3/2	-	1	TC
b)	Routine Test	Test	100%	-do-	TC	3/2	-	1	TC
8.	**Impeller, Casing & Shaft**				TC	3/2	-	1	TC
a)	Chemical composition	Chemical	Sample	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

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QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.40 Cooling Water System (Sheet 4 of 6)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
b)	Mechanical Properties	Mechanical	Sample	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
c)	Hydrostatic Pressure Test of Casing	Test	100%	-do-	TC	3/2	-	1	TC
d)	Dynamic Balancing of Impeller	Visual	100%	-do-	TC	3/2	-	1	TC
9.	**Motor for Pump &Motorized Valve**								
a)	Make, Type & Rating	Visual	100%	-do-	TC	3/2	-	1	TC
b)	Routine Test	Test	100%	-do-	TC	3/2	-	1	TC
10.	**Pump & Motor set**								
a)	Performance Test/Routine Test on Pump & Motor set	Test	100%	-do-	TC	3/2	-	1	TC
b)	Performance Test on Pump & Motor set- Measurement of Rate of Flow, Head, Power Input, Speed & Efficiency and NPSH	Test	100%	-do-	TC	3/2	-	1	TC

Note:

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QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.40 Cooling Water System (Sheet 5 of 6)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
11.	**Shut Off Valve, Non Return Valve, Foot Valve, Maintenance Valve, Check Valve, Purge Valve etc.**								
a)	Chemical Composition	Chemical	Sample	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
b)	Mechanical Properties	Mechanical	Sample	-do-	TC	3/2	-	1	TC
c)	Leakage Test	Test	100%	-do-	TC	3/2	-	1	TC
d)	Pressure Test	Test	100%	-do-	TC	3/2	-	1	TC
12.	**Pipes & Fitting**								
a)	Chemical Composition	Chemical	Sample	-do-	TC	3/2	-	1	TC
b)	Mechanical Properties	Mechanical	Sample	-do-	TC	3/2	-	1	TC
c)	Hydrostatic Pressure Test for Pipes	Test	Sample	-do-	TC	3/2	-	1	TC
d)	Dimension Check	Measurement	100%	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

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QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.40 Cooling Water System (Sheet 6 of 6)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
13.	**Instruments**								
a)	Make, Type , Rating & Calibration	Visual	100%	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
14.	**Pressure Switches, Pressure Gauges & Pressure Reducer**								
a)	Make, Type & Rating	Visual	100%	-do-		3/2	-	1	
b)	Functional Test	Test	100%	-do-		3/2	-	1	TC
15.	**Temperature Sensitive Device (Temperature Gauge, Thermostat etc.)**								
a)	Make, Type , Rating & Accuracy	Visual	100%	-do-	TC	3/2	-	1	TC
b)	Verification Bill of Materials	Visual	100%	-do-	TC	3/2	-	1	TC
c)	Functional Test	Test	100%	-do-	TC	3/2	-	1	TC
d)	IR & HV Test on Control Panel	Elect.	100%	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

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QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.41 **Isolated Phase Bus Duct** (Sheet 1 of 5)

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
	BUS DUCT								
1	Raw Material & Bought – Out Items								
1.1	**Aluminium for Enclosure**								
a)	Dimension	Measurement	100%	Approved Drawings/Technical Spec./IS:5082	TC	3/2	-	1	TC
b)	Mechanical Properties	Mechanical	Sample	-do-	TC	3/2	-	1	TC
c)	Chemical Analysis (Incl. Al Percent)	Chemical	-do-	-do-	TC	3/2	-	1	TC
d)	Conductivity	Electrical	-do-	-do-	TC	3/2	-	1	TC
1.2	**Aluminium for Conductor**								
a)	Dimension	Measurement	100%	-do-	TC	3/2	-	1	TC
b)	Mechanical Properties	Mechanical	sample	do					
c)	Chemical Analysis (Incl. Al Percent)	Chemical	-do-	-do-	TC	3/2	-	1	TC
d)	Conductivity	Electrical	-do-	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

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Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.41 Isolated Phase Bus Duct (Sheet 2 of 5)

NIT/P.O. REFERENCE :

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
1.3	**Epoxy Insulator**								
a)	Dimension	Measurement	-do-	Approved Drawings/Technical Spec./IS:9431	TC	3/2	-	1	TC
b)	Creepage Distance	-do-	-do-	-do-	TC	3/2	-	1	TC
c)	Dry Power Frequency With Stand Test & Partial Discharge	Electrical	-do-	Approved Drawings/Technical Spec.	TC	3/2	-	1	TC
d)	Bending Resistance Test	Mechanical	-do-	Approved Drawings/Technical Spec./IEC:660	TC	3/2	-	1	TC
e)	Thermal Shock Test	test	-do-	Approved Drawings/Technical Spec.	TC	3/2	-	1	TC
1.4	**Expansion Compensator**								
a)	Dimension	Measurement	100%	Approved Drawings/Technical Spec./IS: 5082	TC	3/2	-	1	TC
b)	Mechanical Properties	Mechanical	Sample	-do-	TC	3/2	-	1	TC
c)	Chemical Analysis (Incl. Al Percent)	Chemical	-do-	-do-	TC	3/2	-	1	TC
d)	Conductivity	Electrical	-do-	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.41 Isolated Phase Bus Duct(Sheet 3 of 5)

NIT/P.O. REFERENCE :

S.No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
1.5	**Ethylene –Propylene Bellows**								
a)	Dimension	Measurement	--do-	Approved Drawings/Technical Spec./IS: 5082	TC	3/2	-	1	TC
b)	Mechanical Properties	Mechanical	-do-	-do-	TC	3/2	-	1	TC
c)	Insulation Resistance	Electrical	-do-	-do-	TC	3/2	-	1	TC
2.	**In-Process Inspection**								
2.1	**Bus Duct Enclosure**								
a)	Dimensional Check	Measurement	100%	Approved Drawings/Technical Spec./IS: 5082	TC	3/2	-	1	TC
b)	DNT on Welding	Test	Sample		TC	3/2	-	1	TC
2.2	**Bus Bar Mounting**								
a)	Size of Bus Bar	Visual	Sample	Approved Drawings/Technical Spec./IS: 5082	TC	3/2	-	1	TC
b)	Straightness of Bus Bar	-do-	-do-	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.41 Isolated Phase Bus Duct (Sheet 4 of 5)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
2.3	**Al./Cu. Flexible**								
a)	Alignment, Uniformity Freedom from Defects.	-do-	-do-	Approved Drawings/Technical Spec./IS: 5082	TC	3/2	-	1	TC
b)	Dimensions	-do-	-do-	-do-	TC	3/2	-	1	TC
2.4	**Air Pressurization System**								
i)	BOM Check	-do-	-do-	-do-	TC	3/2	-	1	TC
3.	**Final Inspection**								
3.1	**Type Test**								
i)	Temperature Rise Test	Electrical	One unit	Approved Drawings/Technical Spec./IS: 8084/ANSI	JIR	3/2	1	-	CHP
ii)	Short Time Current Test	-do-	-do-	-do-	JIR	3/2	1	-	CHP
iii)	Impulse Voltage Test	-do-	-do-	-do-	JIR	3/2	1	-	CHP
iv)	One Minute Power Frequency Voltage Withstand Test	-do-	-do-	-do-	JIR	3/2	1	-	CHP

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.41 Isolated Phase Bus Duct (Sheet 5 of 5)

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
v)	Degree of Protection								
a)	Air Tightness Check	Visual	-do-	Approved Drawings/Technical Spec./IS/IEC:439-2	JIR	3/2	1	-	CHP
3.2	**Routine Test**								
i)	Check For Assembly, Dimension ,Tightness of Bus Bar Joints , Bus Bar Support , Clearance & Freedom from Surface Defect & Painting	Visual	100%	Approved Drawings/Technical Spec./IS/IEC:439-2	JIR	3/2	1	-	CHP
ii)	One Minute Power Frequency Voltage Withstand Test	Electrical	100%	Approved Drawings/Technical Spec./IS:8084	JIR	3/2	1	-	CHP
iii)	IR Test before and after HV Test	-do-	-do-	Approved Drawings/Technical Spec./IS Code	JIR	3/2	1	-	CHP
iv)	Mili Volt Drop Test	-do-	Sample	Approved Drawings/Technical Spec./IS:5561	JIR	3/2	1	-	CHP
v)	Checking of Provision For Integration of Air Pressuring System With Plant SCADA System	Visual	-do-	-do-	JIR	3/2	1	-	CHP
vi)	Function & BOM Verification of Air Pressuring System	Visual & Functional	One unit	-do-	JIR	3/2	1	-	CHP

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.42 **LAVT and NG Cubicle** (Sheet 1 of 8)

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
1.	**Raw Material**								
1.1	**Steel Sheet & Angle**								
a)	Dimension	Measurement	100%	Approved Drawings/Technical Spec./IEC & IS	TC	3/2	-	1	TC
b)	Bend Test	Visual	Sample	-do-	TC	3/2	-	1	TC
1.2	**Copper Trip & Flats**								
a)	Dimension	Measurement	100%	-do-	TC	3/2	-	1	TC
b)	Mechanical Test	Mechanical	Sample	-do-	TC	3/2	-	1	TC
c)	Conductivity	Electrical	-do-	-do-	TC	3/2	-	1	TC
2.	**Bought Out Items**								
2.1	**Epoxy Insulator**								
a)	Dimensional	Measurement	-do-	Approved Drawings/Technical Spec./IS:9431	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

Khorlochhu Hydro Power Ltd.

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.42 LAVT and NG Cubicle (Sheet 2 of 8)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
b)	Creepage Distance	Measurement	Sample	Approved Drawings/Technical Spec./IS:9431	TC	3/2	-	1	TC
c)	Dry Power Frequency Withstand Test & Partial Discharge	Electrical	-do-	Approved Drawings/Technical Spec.	TC	3/2	-	1	TC
d	Bending Resistance Test	Mechanical	-do-	Approved Drawings/Technical Spec./IEC:660	TC	3/2	-	1	TC
e)	Thermal Shock Test	Test	-do-	Approved Drawings/Technical Spec.	TC	3/2	-	1	TC
2.2	**Epoxy Seal Off Bushing**	-							
a)	Dimension	Visual	100%	Approved Drawings/Technical Spec./IS Code	TC	3/2	-	1	TC
b)	Dry Power Frequency Withstand Test	Electrical	Sample	-do-	TC	3/2	-	1	TC
c)	Partial Discharge	-do-	-do-	-do-	TC	3/2	-	1	TC
d)	Creepage	-do-	-do-	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.42 LAVT and NG Cubicle (Sheet 3 of 8)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
2.3	**Current Transformer**								
a)	Routine Test	Electrical	Sample	Approved Drawings/Technical Spec./IS:2705/IEC: 185	TC	3/2	-	1	TC
b)	Type Test	Electrical	100%	-do-	TC	3/2	-	1	TC
i.	Impulse Test	-do-	Sample	-do-	TC	3/2	-	1	TC
ii.	Temperature Rise Test	-do-	do	-do-	TC	3/2	-	1	TC
2.4	**Disconnecting Switch**								
i)	Type & No. of Poles	Visual	Sample	Approved Drawings/Technical Spec./IS:9921	TC	3/2	-	1	TC
ii)	Dimension Check	-do-	-do-	-do-	TC	3/2	-	1	TC
iii)	Electrical Operation & Mechanical Operation	Electrical / Mechanical	100%	-do-	TC	3/2	-	1	TC
iv)	Aux .Contact Function	Electrical	-do-	-do-	TC	3/2	-	1	TC
v)	Contract Resistance	-do-	-do-	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
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Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.42 LAVT and NG Cubicle(Sheet 4 of 8)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
vi)	Power Frequency Voltage Test								
a)	Pole & Body	Electrical	-do-	Approved Drawings/Technical Spec./IS:9921	TC	3/2	-	1	TC
b)	Across the Isolating Distance	-do-	-do-	-do-	TC	3/2	-	1	TC
3.	**Neutral Grounding Cubicle**								
3.1	**Neutral Grounding Resistor**								
I)	**Routine Test**								
a)	Visual & Dimensional Check	Visual	100%	Approved Drawings/Technical Spec./IEEE:32	TC	3/2	-	1	TC
b)	Resistance at Amb.Temp	Electrical	-do-	-do-	TC	3/2	-	1	TC
c)	Insulation Resistance	-do-	-do-	-do-	TC	3/2	-	1	TC
d)	H.V Withstand Test	-do-	-do-	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

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(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.42 LAVT and NG Cubicle (Sheet 5 of 8)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
II)	**Type test**								
a)	Short Time Duty Test	Electrical	Sample	Approved Drawings/Technical Spec./IEEE:32	TC	3/2	-	1	TC
b)	Continuous Duty Test	-do-	-do-	-do-	TC	3/2	-	1	TC
3.2	**Neutral Grounding Transformer**								
a)	Routine Test	Electrical	100%	Approved Drawings/Technical Spec./IS:11171	TC	3/1	-	1	TC
b)	Type Test	-do-	Sample	-do-	TC	3/2	-	1	TC
i.	Temperature Rise Test	Electrical	Sample	Approved Drawings/Technical Spec./IS:11171	TC	3/2	-	1	TC
ii.	Impulse Test	-do-	-do-	-do-	TC	3/2	-	1	TC
4.	**LAVT Cubicle**								
4.1	**Voltage Transformer**								
a)	Routine Test	Electrical	100%	Approved Drawings/Technical Spec./IS:3156 & IEC:186	TC	3/2	-	11	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
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Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.42 LAVT and NG Cubicle (Sheet 6 of 8)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
b)	Type Test								
i	Impulse Test	Electrical	100%	Approved Drawings/Technical Spec./IS:3156 & IEC:186	TC	3/2	-	1	TC
ii	Heat Run Test	-do-	Sample	-do-	TC	3/2	-	1	TC
4.2	**Lightning Arrestor**						-	1	TC
a)	Visual & Dimension	Measurement	100%	Approved Drawings/Technical Spec./IS:3070	TC	3/2	-	1	TC
b)	Routine Test (Measurement of Reference Voltage, Lightning Impulse Residual Voltage, Partial Discharge & Seal Leak Test etc.)	Electrical	-do-	-do-	TC	3/2	-	1	TC
c)	Type Test	-do-	Sample	-do-	TC	3/2	-	1	TC
4.3	**Surge Capacitor**						-	1	TC
a)	Visual	Measurement	100%	Approved Drawings/Technical Spec./IS:11548	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.42 LAVT and NG Cubicle (Sheet 7 of 8)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
b)	Routine Test								
i.	Output Test (Capacitance & Tan Delta)	Electrical	100%	Approved Drawings/Technical Spec./IS:11548	TC	3/2	-	1	TC
ii.	Voltage Test between Terminals	-do-	-do	-do	TC	3/2	-	1	TC
iii.	Efficiency Test (Discharge up to Minimum Voltage)	-do-	-do-	-do-	TC	3/2	-	1	TC
iv.	Sealing Test	-do-	-do-	-do	TC	3/2	-	1	TC
c)	Type Test	-do-	Sample	-do-	TC	3/2	-	1	TC
4.4	**Earthing Switch**								
a)	Type Test	Electrical	100%	Approved Drawings/Technical Spec./IEC:129	TC	3/2	-	1	TC
b)	Routine Test	-do-	-do-		TC	3/2	-	1	TC
4.5	**H.T fuse**								
a)	Continuity test	Electrical	-do-	Approved Drawings/Technical Spec./IEC:129	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.42 LAVT and NG Cubicle (Sheet 8 of 8)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
4.6	**Mounting structure**								
a)	Dimension Check	Measurement	100%	Approved Drawings/Technical Spec.	TC	3/2	-	1	TC
b)	Uniformity , Mass and Adhesion of Zn Coating	-do-	-do-	-do-	TC	3/2	-	1	TC
5.	**Final Inspection**								
i)	Check for BOM, Layout, Dimension, Joints, Clearance & Freedom from Surface Defects	Visual	100%	-do-	JIR	3/2	1	-	CHP
ii)	Scheme Checking	Electrical	-do-	Approved Drawings/Technical Spec./IS Code	JIR	3/2	1	-	CHP
iii)	HV & IR Test on Main and Auxiliary Circuit , Continuity Check	-do-	-do-		JIR	3/2	1	-	CHP
iv)	Heater & Thermostat								
a)	Type & Rating	Visual	-do-	Approved Drawings/Technical Spec.	JIR	3/2	1	-	CHP
b)	Functional Test	Test	-do-	-do-	JIR	3/2	1	-	CHP
v)	Painting (Uniformity, Adhesion & Shade)	Visual	-do-	-do-	TC	3/2	-	1	TC
vi)	Degree of Protection	-do-	-do-	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client)

Signature (Consultant)

Signature & Seal (Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.43 **Grounding and Lightning Protection System** (Sheet 1 of 3)

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
1.	**Raw Materials**								
1.1	**Rods/Wires**								
a)	Physical Properties	Physical	10% Sample	Approved Drawings/Technical Spec./IS:613, IS:8130	TC	3/2	-	1	TC
b)	Chemical Composition & Purity	Chemical	-do-	-do-	TC	3/2	-	1	TC
c)	Dimension	Measurement	-do-	-do-	TC	3/2	-	1	TC
2.	**In-Process**								
2.1	**Wire Drawing and Annealing**								
a)	Physical Properties	Physical	100%	Approved Drawings/Technical Spec./IS:8130	Log book	3/2	-	2	RR
b)	Finish & Dimension	Visual & Measurement	Spool at start & end	-do	Log book	3/2	-	2	RR
c)	Per-Sulphate Test (for Tinned Conductor)	Chemical	1/Type	-do-	Log book	3/2	-	2	RR

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.43 Grounding and Lightning Protection System (Sheet 2 of 3)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
2.2	**Stranding of Wires**								
a)	Number of Wires	Counting	Sample	Approved Drawings/Technical Spec./IS:8130	Log book	3/2	-	2	RR
b)	Surface Finish	Visual	-do-	-do-	Log book	3/2	-	2	RR
c)	Dimension	Measurement	-do-	-do-	Log book	3/2	-	2	RR
d)	Resistance	Electrical	100%	-do-	Log book	3/2	-	2	RR
3.	**Final Inspection**								
a)	Surface Finish	Visual	100% Drum	-do-	TC	3/2	-	1	TC
b)	Dimension & Length	Measurement	-do-	-do-	TC	3/2	-	1	TC
b)	Conductor Resistance	Electrical	-do-	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.43 Grounding and Lightning Protection System (Sheet 3 of 3)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
4.	**Packing**								
a)	Marking on Drums	Visual	100%	Technical Spec./Relevant IS Code	Log book	3/2	-	2	RR
b)	Dimension of Members of Drums Construction	Measurement	100%	Technical Spec./IS:10418	Log book	3/2	-	2	RR
c)	Rust Prevention of Hard Ware	Visual	100%	Technical Spec./Relevant IS:2629,IS:2633	Log book	3/2	-	2	RR
5.	**Field Tests**								
a)	Physical Verification	Visual	100%	Technical Spec.	JIR	3/2	1	-	CHP*
b)	Continuity Test	Electrical	100%	Technical Spec./Relevant IS Code	JIR	3/2	1	-	CHP*
c)	Measurement of Earthing Resistance of individual loops.	Electrical	100%	Technical Spec./Relevant IS Code	JIR	3/2	1	-	CHP* *To be witnessed by KHEP site engineers

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.44 **Drainage and Dewatering System** (Sheet 1 of 3)

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
1.	**Pump Motor Set**								
a)	Make, Model & Capacity	Visual	100%	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
2.	**Impeller, Casing, Shaft & Fasteners**								
a)	Mechanical Strength	Mechanical	Sample	-do-	TC	3/2	-	1	TC
b)	Chemical Composition	Chemical	-do-	-do-	TC	3/2	-	1	TC
c)	Water Tightness Test-Pump Body/Casing	Test	100%	-do-	TC	3/2	-	1	TC
d)	Dynamic Balancing of Impeller	Test	100%	-do-	TC	3/2	-	1	TC
3.	**Strainer**								
a)	Chemical Composition	Chemical	Sample	-do-	TC	3/2	-	1	TC
b)	Mesh /Perforation Size	Measurement	100%	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.44 Drainage and Dewatering System (Sheet 2 of 3)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
4.	**Pipes, Fittings, Valves & Flanges**								
a)	Mechanical Strength	Mechanical	Sample	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
b)	Chemical Composition	Chemical	-do-	-do-	TC	3/2	-	1	TC
c)	Dimensional Check	Measurement	100%	-do-	IR	3/2	-	1	RR
d)	Hydrostatic Test	Test	-do-	-do-	TC	3/2	-	1	TC
5.	**Level Switches, Flow Meters, Pressure Switches, Pressure Gauges & level Indicators etc.**								
a)	Make, Model, Rating & Calibration	Visual	100%	-do-	TC	3/2	-	1	TC
6.	**Motor Routine Test (Submersible Pump)**								
a)	HV & Insulation resistance Test	Electrical Test	100%	Approved Drawings/Technical Spec./IS:9283	TC	3/2	-	1	TC
b)	No load Running Test	Electrical Test	-do-	-do-	TC	3/2	-	1	TC
c)	Locked Rotor Test	Electrical Test	-do-	-do-	TC	3/2	-	1	TC
d)	Reduced Voltage Running Test	Electrical Test	-do-	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.44 Drainage and Dewatering System(Sheet 3 of 3)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
7.	**Power Cable for Submersible Pump (Routine Test)**								
a)	Conductor Resistance Test	Electrical Test	100%	Approved Drawings/Technical Spec./IS:1554	TC	3/2	-	1	TC
b)	HV Test	Electrical Test	100%	-do-	TC	3/2	-	1	TC
8.	**Pump & Motor Set (Submersible Pump)**								
a)	Performance Test on Pump & Motor Set	Test	100%	Approved Drawings/Technical Spec./Relevant Standard/IS:8034/IS:11346	TC	3/2	-	1	TC
b)	Performance Test on Pump & Motor set-Measurement of Rate of Flow, Head, Power Input, Speed & Efficiency and HPSH(If required)	Test	One unit of each type	-do-	TC	3/2	-	1	TC
9.	**Control Panel**								
a)	Verification of Bill of Materials	Visual &Test	100%	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
b)	Functional Test	Test	-do-	-do-	TC	3/2	-	1	TC
c)	IR & HV Test on Control Panel	Electrical	-do-	Approved Drawings/Technical Spec./IS:8623	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client)

Signature (Consultant)

Signature & Seal (Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

NIT/P.O. REFERENCE :

1.45 **Compressed Air System** (Sheet 1 of 5)

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
1.	**Compressor Unit**								
a)	Make ,Type & Capacity	Visual	100%	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
b)	Routine Test	Test	-do-	-do-	TC	3/2	-	1	TC
2.	**House pipes**								
a)	Make &Size	Visual	100%	-do-	TC	3/2	-	1	TC
b)	Pressure Test	Test	100%	-do-	TC	3/2	-	1	TC
3.	**Pipes, Fittings, Pressure Reducer, Valves & Flange**								
a)	Chemical Composition	Chemical	Sample/Batch	-do-	TC	3/2	-	1	TC
b)	Mechanical Strength	Mechanical	-do-	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature
KHPL (Client)

Signature
(Consultant)

Signature & Seal
(Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.45 Compressed Air System (Sheet 2 of 5)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
c)	Dimensional Checks	Measurement	100%	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	
d)	Pressure Test	Test	100%	-do-	TC	3/2	-	1	TC
e)	Functional Test of Valves	Test	100%	-do-	TC	3/2	-	1	TC
4.	**Motor**								TC
a)	Make. Type &making	Visual	100%	-do-	TC	3/2	-	1	TC
b)	Routine Test	Test	Visual	Approved Drawings/Technical Spec./Relevant Standard/IS:325	TC	3/2	-	1	TC
5.	**Pressure Gauge, Temperature Indicator & Switches**								TC
a)	Make, Type & Calibration	Visual	Visual	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
6.	**Air & Oil filters**								
a)	Make. Type & Rating	Visual	100%	-do-	TC	3/2	-	1	TC
b)	Mesh Size	Measurement	100%	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client) **Signature (Consultant)** **Signature & Seal (Vendor)**

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.45 Compressed Air System (Sheet 3 of 5)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
7.	**Air Dryer**								
7.1	**Fan & Motor**								
a)	Make, Type & Making	Visual	-do-	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
b)	Routine Test	Test	-do-	Approved Drawings/Technical Spec./Relevant Standard/IS:11989	TC	3/2	-	1	TC
7.2	**Heating Element**								
a)	Make, Model & Capacity	Measurement	-do-	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
8.	**Air Receiver(Pressure Vessel Steel)**								
a)	Chemical composition	Chemical	Sample/Batch	Approved Drawings/Technical Spec./Relevant Standard/IS:2825	TC	3/2	-	1	TC
b)	Mechanical Strength	Mechanical	-do-	-do-	TC	3/2	-	1	TC
c)	NDT of Plate	UT	100%	-do-	TC	3/2	-	1	TC
d)	NDT-Full Strength Weld	DPT/RT	100%	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

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QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.45 Compressed Air System (Sheet 4 of 5)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
e)	Post Weld Stress Relieving	Temperature Regulation	100%	Approved Drawings/Technical Spec./Relevant Standard/IS:2825					
f)	Dimensional Check	Test	-do-	-do-	TC	3/2	-	1	TC
g)	Hydrostatic Test of Air Receiver	Test	-do-	Approved Drawings/Technical Spec./Relevant Standard/IS:7938	TC	3/2	-	1	TC
h)	Painting-DFT	Measurement	-do-	Approved Drawings/Technical Spec./Relevant Standard	TC	3/2	-	1	TC
9.	**Compressor Assemble including Control Panel**								
a)	Dimensional Check	Measurement	-do-	-do-	TC	3/2	-	1	TC
b)	Acceptance Test								
i)	Capacity (Free Air Delivery)	Measurement	-do-	-do-	JIR	3/2	1	-	CHP
ii)	Speed	-do-	-do-	-do-	JIR	3/2	1	-	CHP
iii)	Specific Power Consumption at full load	-do-	-do-	-do-	JIR	3/2	1	-	CHP
iv)	Noise level	-do-	-do-	-do-	JIR	3/2	1	-	CHP

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

c. Test certificates shall be submitted at the time of final inspection.

Signature KHPL (Client)

Signature (Consultant)

Signature & Seal (Vendor)

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : KHORLOCHHU HPP

CLIENT : KHORLOCHHU HYDRO POWER LIMITED

VENDOR NAME AND ADDRESS :

1.45 Compressed Air System (Sheet 5 of 5)

NIT/P.O. REFERENCE :

S. No.	Item/Component & Characteristics	Nature of Checks	Quantum of Check	Reference Document/Acceptance Norms	Record Format	Inspection Agency			Remarks
						Perform	Witness	Verify	
c)	Verification of Bill of Materials	Visual	100%	Approved Drawings/Technical Spec./Relevant Standard	JIR	3/2	1	-	CHP
d)	Functional Test	-do-	-do-	-do-	JIR	3/2	1	-	CHP
e)	IR & HV Test on Control Panel	Electrical	-do-	-do-	TC	3/2	-	1	TC
10.	**Painting & Preservation**	Measurement	-do-	-do-	TC	3/2	-	1	TC

Note:

a. In 'Inspection Agency' column figure 1, 2 or 3 to be filled. 1- Will indicate 'KHPL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.

b. In 'Remarks' column following abbreviations shall be used - RR - Review of Records, T.C.- Test Certificate Submission, JIR - Joint Inspection Report & CHP - Customer Hold Point.

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Signature & Seal
(Vendor)

KHORLOCHHU HYDRO POWER LIMITED

4x150 MW KHORLOCHHU HYDROPOWER PROJECT

TRASHIYANGTSE; BHUTAN

BIDDING DOCUMENT

FOR

CONTRACT PACKAGE: KEM-1

DESIGN, MANUFACTURING, SUPPLY, INSTALLATION, TESTING AND COMMISSIONING OF ELECTRO-MECHANICAL WORKS

VOLUME - 5

TENDER DRAWINGS

International Competitive Bidding

These documents are meant for the exclusive purpose of bidding against this NIT and shall not be transferred, reproduced or otherwise used for purposes other than that for which they are specifically issued.

Tender Ref. No. KHPL/C&PD/TENDER:KEM-1/2025/11534 dt. 07.08.2025

LAYOUT OF BIDDING DOCUMENTS
CONTRACT PACKAGE: KEM-1
Design, Manufacturing, Supply, Installation, Testing and Commissioning of Electro-Mechanical Works

Volume - 1: Instructions to Bidders (ITB)

- Section - 1 Abridged Notice Inviting Tender and Notice Inviting Tender (NIT)
- Section - 2 Instructions to Bidders (ITB), Bid Data, Qualification Forms, Information for Bidders (IFB) and Work Schedule

Volume - 2: General Conditions of Contract (GCC) and Particular Conditions of Contract (PCC)

- Section - 3 FIDIC General Conditions of Contract (GCC) for Plant and Design-Build Contract (First Edition 1999)
- Section - 4 Particular Conditions of Contract (PCC)
- Section - 5 Forms and Procedures
  - Form-1: Letter of Tender
  - Form-2: Form of Contract Agreement
  - Form-3: Bank Guarantee Form for Performance Security
  - Form-4: Bank Guarantee Form for Advance Payment
  - Form-5: Form of Taking Over Certificate
  - Form-6: Bank Guarantee Form for Release of Retention Money
  - Form-7: Hindrance Register
  - Form-8: Dispute Adjudication Agreement
  - Form-9: Parent/Holding Company Agreement
  - Form-10: Proforma for Joint Deed of Undertaking

Volume-3: Price Schedules

Volume-4: Employer's Requirements

- Section - 6 General Technical Specifications (GTS)
- Section - 7 Particular Technical Specifications (PTS)
- Section - 8 Quality Assurance Plan (QAP)

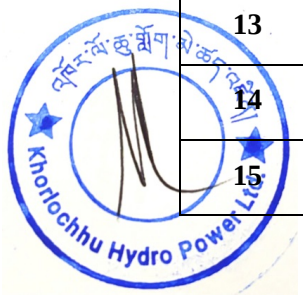
Volume-5: Tender Drawings

Volume-6: Technical Data Sheets



INDEX

Sl. No.	Drawing	Description
1	**KHPP-HM-GEN-SI-6001**	LOCATION MAP
2	**KHPP-HM-GEN-GA-6002**	LAYOUT OF PROJECT CUM MASTER PLAN
3	**KHPP-CV-DM-GA-30001**	DAM – PLAN & LS AT DAM AXIS
4	**KHPP-CV-CDW-GA-30002**	CHAPLANGCHHU DIVERSION WORKS-PLAN & LS
5	**KHPP-CV-HRT-GA-30003**	HRT: PLAN AND ADIT DETAILS
6	**KHPP-CV-SS-GA-30004**	SURGE SHAFT: PLAN & CROSS SECTION
7	**KHPP-CV-PS-GA-30005**	PRESSURE SHAFT: PLAN & LS
8	**KHPP-CV-TRT-GA-30006**	TAILRACE TUNNEL: PLAN & OUTLET PORTAL
9	**KHPP-CV-CAT-GA-30007**	CABLE ACCESS TUNNEL: PLAN, LS & CROSS SECTION
10	**KHPP-EL-PH-SLD-4006-AU-40001**	KEY SINGLE LINE DIAGRAM
11	**KHPP-EL-PH-SLD-4006-AU-40002**	METERING AND PROTECTION SYSTEM SINGLE LINE DIAGRAM
12	**KHPP-EL-PH-SLD-4006-AU-40003**	MV & LV DISTRIBUTION SINGLE LINE DIAGRAM
13	**KHPP-EL-PH-SLD-4006-AU-40004**	132kV SWITCHYARD SINGLE LINE DIAGRAM
14	**KHPP-EL-PH-SLD-4006-AU-40005**	DC SYSTEM SINGLE LINE DIAGRAM SHEET-1 OF 2
15	**KHPP-EL-PH-SLD-4006-AU-40005**	DC SYSTEM SINGLE LINE DIAGRAM SHEET-2 OF 2



Sl. No.	Drawing	Description
16	**KHPP-EL-PH-4006-AU-40006**	400 kV POTHEAD YARD SINGLE LINE DIAGRAM
17	**KHPP-ME-6017-GA-60001 (SHEET-1)**	POWERHOUSE CROSS SECTION
18	**KHPP-ME-6017-GA-60001 (SHEET-2)**	MIV FLOOR (EL.769.50m) TURBINE FLOOR (EL.775.00m) GENERATOR FLOOR (EL.779.50m)
19	**KHPP-ME-6017-GA-60001 (SHEET-3)**	LAYOUT OF MACHINE HALL, BUSDUCT GALLERIES AND TRANFORMER HALL (EL.784.00m
20	**KHPP-ME-6017-GA-60001 (SHEET-4)**	TRANSFORMER HALL LONGITUDINAL SECTION AND GIS FLOOR PLAN
21	**KHPP-ME-6017-GA-60001 (SHEET-5)**	POWERHOUSE LONGITUDINAL SECTION
22	**KHPP-ME-6017-GA-60001 (SHEET-6)**	ANNEXE FLOOR PLANS, POWERHOUSE AND TRANSFORMER HALL
23	**KHPP-ME-6017-GA-60001 (SHEET-7**	POWERHOUSE COMPLEX LAYOUT PLAN
24	**KHPP-ME-6017-GA-60003**	LAYOUT ARRANGEMENT OF BFV CHAMBER
25	**KHPP-ME-6017-PI-60004**	LP COMPRESSOR AIR SYSTEM
26	**KHPP-ME-6017-PI-60005**	COOLING WATER SYSTEM SCHEMATIC DIAGRAM
27	**KHPP-ME-6017-PI-60006**	VENTILATION SYSTEM SCHEMATIC DIAGRAM
28	**KHPP-ME-6017-PI-60007**	FIRE FIGHTING PROTECTION SYSTEM SCHEMATIC DIAGRAM
29	**KHPP-ME-6017-PI-60008**	DRAINAGE & DEWATERING SYSTEM SCHEMATIC DIAGRAM



DWG NO KHPP-HM-GEN-SI-6001

TITLE LOCATION MAP

CHINA

GASA

PUNAKHA

THIMPHU

PARO

HAA

WANGDUSPHODRANG

DAGANA

TSIRANG

Damphu

SAMTSE

CHUKHA

Phuetsholing

BUMTHANG

Jakar

LHUNTSE

TRASHI YANGTSE

KHOLONGCHHU HEP(600 MW)

TRONGSA

ZHEMGANG

SARPANG

TRASHIGANG

MONGAR

PEMA GATSHAL

NAKOR

CHHENARI

SAMDRUP JONGKHAR

ENTRY POINT

INDIA

GUWAHATI

LEGEND:-

ROAD

INTERNATIONAL BOUNDARY

NOTES :-

1. THIS DRAWING SHOWS THE LOCATION MAP OF KHOLONGCHHU HE PROJECT AREA.

Guwahati to Samdrup Jhonkar/Darnga	110 Km.
Samdrup Jhonkar to Trashigang	180 Km.
Trashigang to Chazam	14 Km.
Chazam to Power House site	10 Km.
Power house site to Duksum	5 Km.
Duksum to Dam Site	17 Km.
Dam Site to Trashiyangtse	8 Km.
Duksum to Trashiyangtse	25 Km.
Paro airport to Dam site	620 Km.
Nearest airport Guwahati (India)	320 Km.
Rangia(Assam) India to Damsite	270 Km.

Khorlochhu Hydro Power Ltd.

FOR TENDER PURPOSE

CLIENT: KHORLOCHHU HYDRO POWER LIMITED, TRASHIYANGTSE, BHUTAN

CONSULTANT: Tata Consulting Engineers Ltd. & Lombardi Engineering Ltd.(JV)

PROJECT: KHORLOCHHU HYDRO POWER PROJECT(4X150 MW), TRASHIYANGTSE, BHUTAN

TITLE: LOCATION MAP

FILE NAME: KHPP-HM-GEN-SI-6001

"P" (PRELIMINARY) ISSUES ARE NOT TO BE USED FOR CONSTRUCTION/FABRICATION BUT ARE ISSUED FOR LIMITED PURPOSES ONLY AS INDICATED IN THE SMALL BLOCK AT THE TOP RIGHT HAND CORNER OF THE TITLE BLOCK.

CONSTRUCTION/FABRICATION WORK IS PERMITTED ON "R" (RELEASED) ISSUES ONLY.

INFORMATION CONTAINED WITHIN "HOLD" IS NOT RELEASED FOR CONSTRUCTION/ FABRICATION. FIELD MUST GET DESIGN OFFICE TO CLEAR HOLD WITH TIME BEFORE PROCEEDING WITH ANY CONSTRUCTION/FABRICATION WORK RELATED TO "HOLD".

APPVD.	GVR.	MECH.	INSTL.	ELEC.	STR.	ARCH. REVIEWED	NATURE OF REVISION & DESCRIPTION	CHECKED	DRAWN	REV.	DATE

DESIGNED: JC / RKR	CHECKED: LGC	RECOMMENDED:
DRAWN : ZMT	APPROVED: PLN	
DWG No: KHPP-HM-GEN-SI-6001		
SCALE: AS SHOWN	ISSUE P1	DATED: 18-JUN-2025 ORIGINAL PRINT SIZE: A1

Sl.#	Name of Road	Length (m)	To be black toped and maintained by
1	Access Road to Contractors Facility area at Dam	403	KC#1
2	Access Road from NH to Dam Bridge Point	907	
3	Access Road to Adit-I from Dam Bridge Point	1700	
4	Access Road to magazine	200	
5	Access Road from Shali Junction (on NH on left bank) to Junction at Adit-III & Adit-IV on right bank	6840	KC#2
6	Access Road to Adit-V from Tomshang Geog Road	668	
7	Access Road from Tomshang school to Adit-IV	2735	
8	Access Road from Adit-IV to Adit-III	3560	
9	Access Road from Adit-III to Adit-II	4440	
10	Access Road to Contractors Facility area at Lakurung for HRT Package	184	
11	Access Road to Surge shaft top from Nynda Junction	4296	
12	Access Road to Adit-VI bifurcating from Surge shaft Road	860	
13	Access Road to Intermediate Adit-I to Pressure shaft from Bainangkhar Kurlung Geog Road	1724	KC#3
14	Access Road to Intermediate Adit-II to Pressure shaft from Bainangkhar Kurlung Geog Road	1602	
15	Access Road to TRT Outfall from National Highway	580	
16	Access Road to Magazine at Tshergom from Jamkhar Geog Road	382	
17	Primary National Highway at Korlung	1300	
18	Distance of aggregate pick up/feed point from old duksum town	5000	

Sl.#	Name of River Sand quarry	Location
1	Tshangsingma	3-4 km above old Duksum Town along Drangmechhu
2	Dungsekhar	9-10 km from Dam site above Cremation ground. along Kholongchhu
3	Domdee	12 km D/S of Chazam bridge along Drangmechhu
4	Thsergom Chencheri Manidhangri Retshalowoom Tshoshingthang Buna Lungtenzampa Kharpalhaptsa Dhawoon Betshalu	All these sand quarry is located within 15-30 km radius from the project area along Drangmichhu
5	Kurichhu	Approx. 130 km away from Project area at Mongar along kurichhu

NOTE : -

1. Specification Drawing for BID Purpose only
2. The Sacred/Religious sites marked (Sl.No.1 to 21) indicated approximate location of Sacred/religious sites for which the contractor shall take due care of preserve and protect. Mandatory provisions for such diligence have been stipulated in the Bidding document.
3. Location of Choetens/ Lhakhangs are not indicated in the map.



Khorlochhu Hydro Power Ltd.

FOR TENDER PURPOSE

CLIENT: KHORLOCHHU HYDRO POWER LIMITED
TRASHIYANGTSE, BHUTAN

CONSULTANT:
Tata Consulting Engineers Ltd. &
Lombardi Engineering Ltd.(JV)

PROJECT: KHORLOCHHU HYDRO POWER PROJECT(4X150 MW), TRASHIYANGTSE, BHUTAN

TITLE: LAYOUT OF PROJECT CUM MASTER PLAN

DESIGNED: JC / RKR	CHECKED: LDC	RECOMMENDED:
DRAWN : ZMT	APPROVED: PLN	

DWG No: KHPP-HM-GEN-GA-5002

SCALE: AS SHOWN | ISSUE: P1 | DATE: 18-JUN-2026 | ORIGINAL PRINT SIZE: A1

FILE NAME: KHPP-HM-GEN-GA-5002

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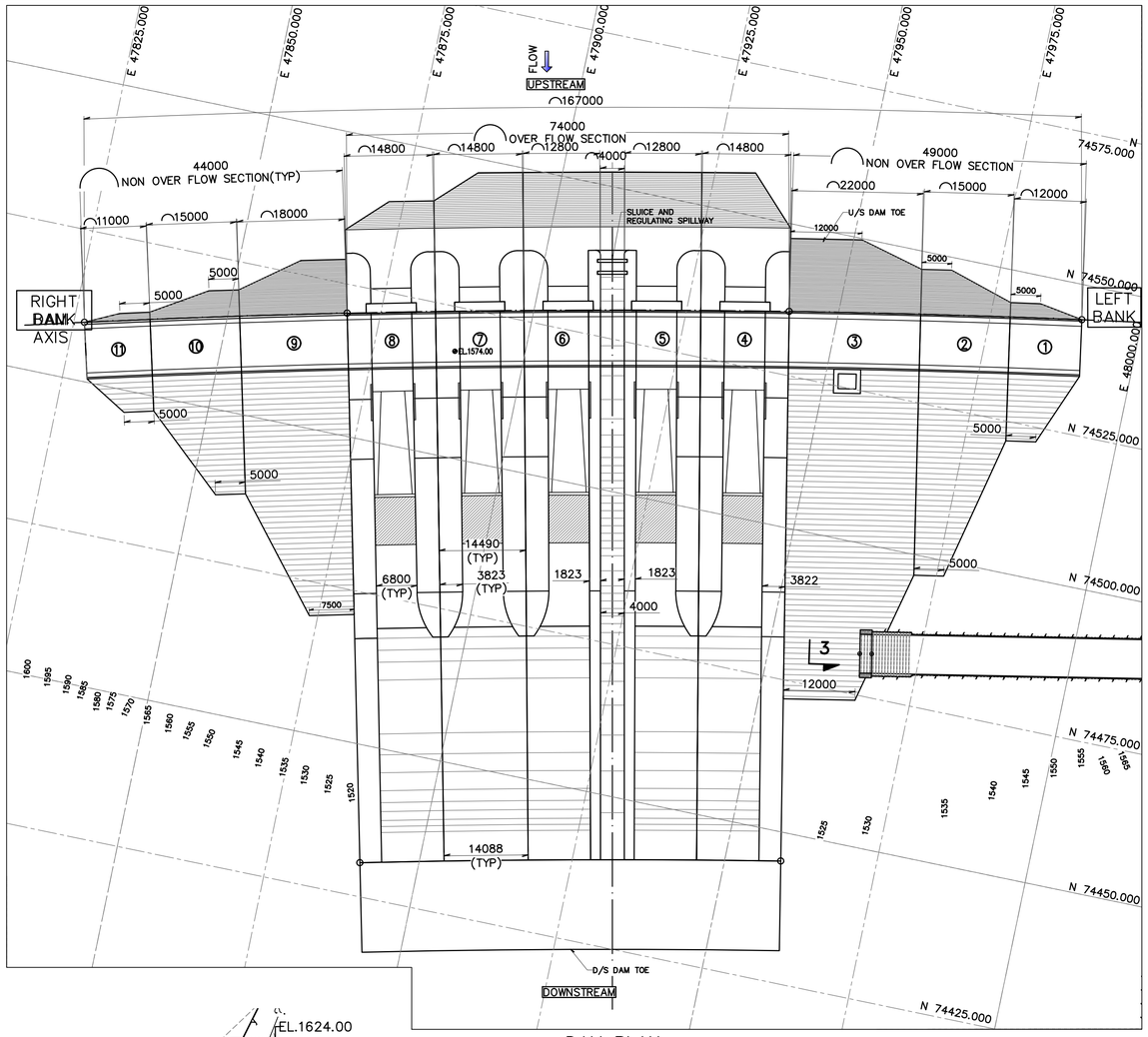
BY/CH'K	SYM.	MECH.	INSTL.	ELEC.	STR.	ARCH.	NATURE OF REVISION & DESCRIPTION	CHECKED	DRAWN	REV.	DATE
				REVISED							

DWG NO: KHPP-HM-GEN-GA-5002

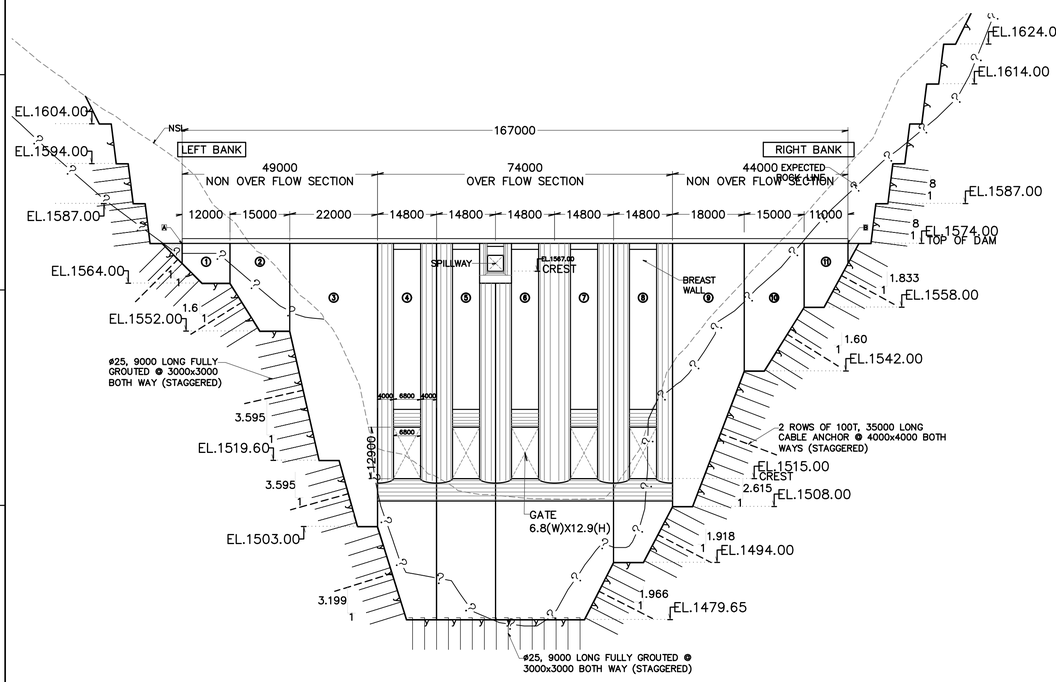
TITLE: LAYOUT OF PROJECT CUM MASTER PLAN

TITLE: DAM PLAN & L-S @ DAM AXIS

DWG NO KHPP-CV-DM-GA-30001



DAM PLAN
1:500



L-SECTION AT DAM AXIS
1:400

LEGEND

NSL	– NATURAL SURFACE LEVEL
℄	– CENTER LINE
----------	– NSL LINE
–?–?–	– EXPECTED ROCK LINE
→→→→	– EXCAVATION LINE

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETER AND ELEVATIONS ARE IN METERS, UNLESS OTHERWISE SPECIFIED.
2. NO DIMENSION SHALL BE MEASURED FROM THE DRAWING, ONLY WRITTEN DIMENSION SHALL BE FOLLOWED.

FOR TENDER PURPOSE ONLY

CLIENT: KHORLOCHHU HYDRO POWER LIMITED
TRASHIYANGTSE, BHUTAN

CONSULTANT: Tata Consulting Engineers Ltd. & Lombardi Engineering Ltd.(JV)

PROJECT: KHORLOCHHU HYDRO POWER PROJECT(4X150 MW), TRASHIYANGTSE, BHUTAN

TITLE: DAM PLAN & L-S @ DAM AXIS

DESIGNED: SK	CHECKED: PB	RECOMMENDED:
DRAWN : ZMT	APPROVED: PLN	
DWG No: KHPP-CV-DM-GA-30001		
SCALE: AS SHOWN	ISSUE P1	DATE: 08-AUG-2025 / ORIGINAL PRINT SIZE: A1

FILE NAME: KHPP-CV-DM-GA-30001

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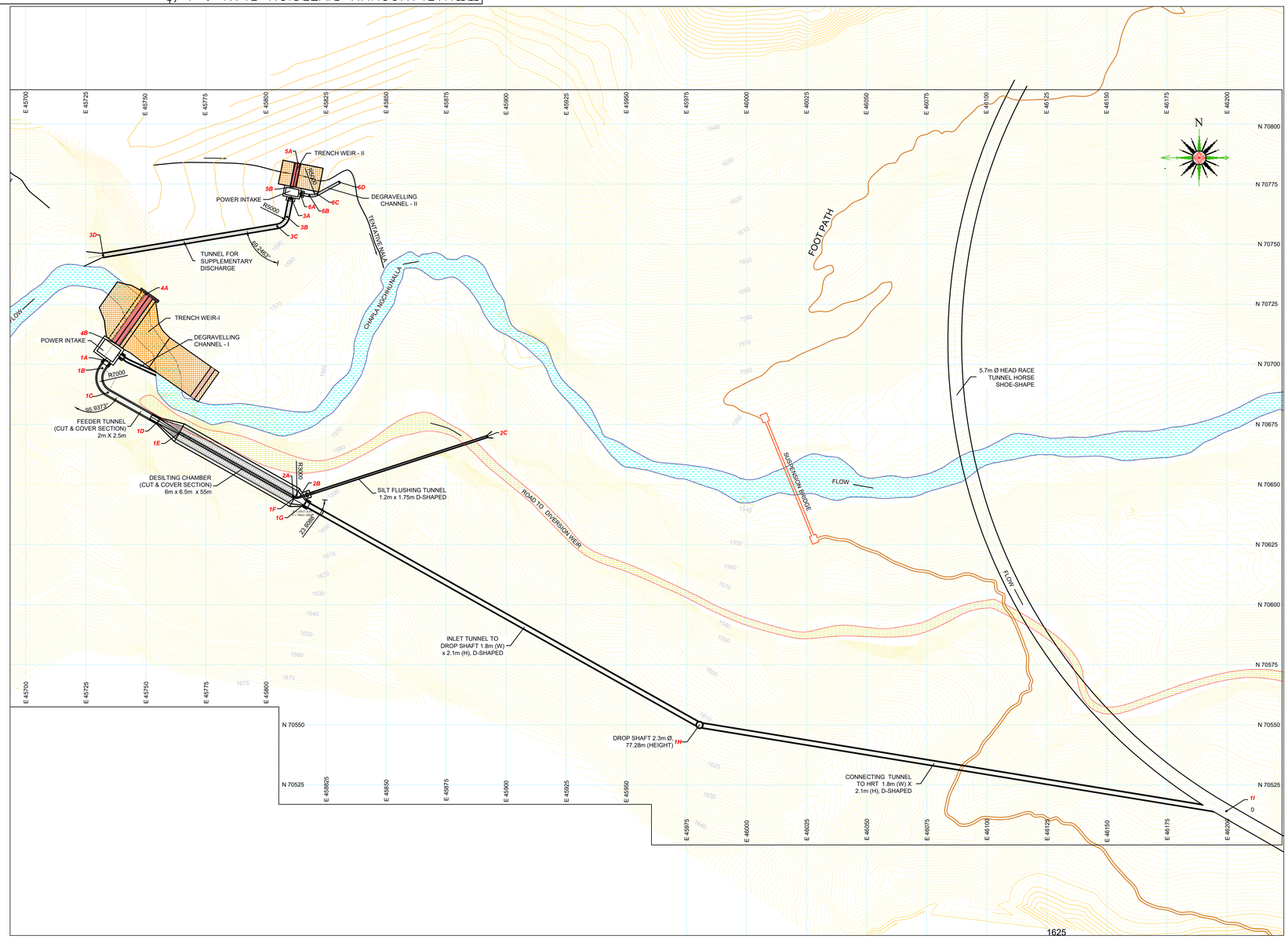
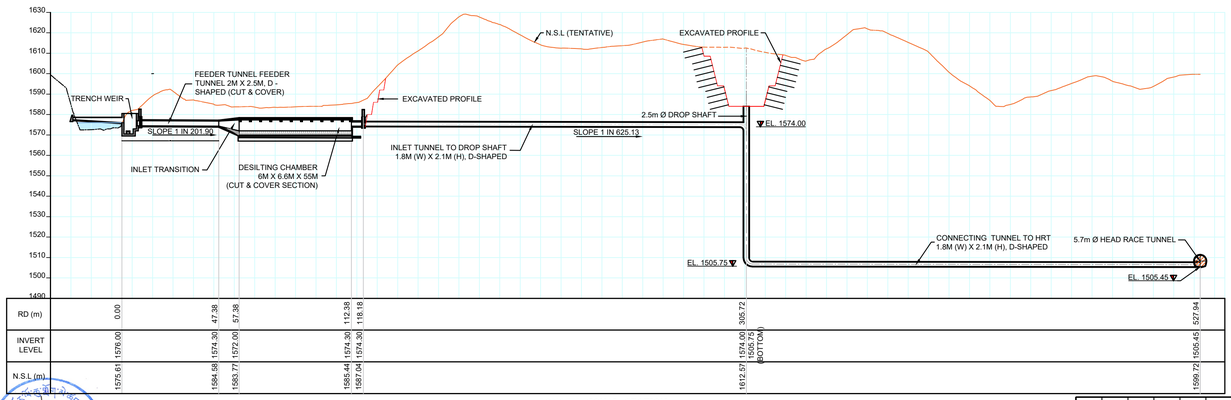
APPROV.	CIVIL	MECH.	INST.	ELEC.	STRL.	ARCH.	REVIEWED	NATURE OF REVISION & DESCRIPTION	CHECKED	DRAWN	REV.	DATE

TITLE: CHAPLANGCHHU DIVERSION PLAN & L/S

DWG NO: KHPP-CV-CDW-GA-30002





RD (m)	0.00	47.38	57.38	112.38	118.18	305.72	527.64				
INVERT LEVEL	1576.00	1574.30	1572.00	1574.30	1574.30	1514.00 (1505.75 (BOTTOM))	1505.45				
N.S.L (m)	1575.61	1584.58	1583.77	1585.44	1587.04	1612.57	1599.72				

LONGITUDIONAL SECTION

NOTES:

1. ALL DIMENSIONS ARE IN MM AND ELEVATIONS IN METRES.
2. THE DIMENSIONS SHALL NOT BE SCALED. ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED.
3. LEVELS AND ELEVATIONS SHOWN IN THIS DRAWINGS ARE TENTATIVE.
3. LAYOUT OF CHAPLANGCHHU WORKS MAY CHANGE DEPENDING UPON THE DETAILED TOPOGRAPHICAL, GEOLOGICAL INVESTIGATIONS DURING THE DETAILED DESIGN ENGINEERING STAGE.
4. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH DRG. NO. CD-KHEP-BID-01/R0 (SHEET 1 OF 7) & CD-KHEP-BID-02/R0 (SHEET 2 OF 7).

FOR TENDER PURPOSE ONLY

CLIENT:
KHORLOCHHU HYDRO POWER LIMITED
TRASHIYANGTSE, BHUTAN

CONSULTANT:
Tata Consulting Engineers Ltd. &
Lombardi Engineering Ltd.(JV)

PROJECT:
KHORLOCHHU HYDRO POWER PROJECT(4X150 MW), TRASHIYANGTSE, BHUTAN

TITLE:
CHAPLANGCHHU DIVERSION PLAN & L/S

DESIGNED: SK	CHECKED: PB	RECOMMENDED:	
DRAWN : ZMT	APPROVED: PLN		
DWG No: KHPP-CV-CDW-GA-30002			
SCALE: AS SHOWN	ISSUE P1	DATE: 08-AUG-2025	ORIGINAL PRINT SIZE: A1

FILE NAME: KHPP-CV-CDW-GA-30002

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APPROV.	REVIEWED: CIVIL	MECH.	INST.	ELEC.	STRL.	ARCH.	NATURE OF REVISION & DESCRIPTION	CHECKED	DRAWN	REV.	DATE

Khorlochhu Hydro Power Ltd.

TITLE: HEAD RACE TUNNEL PLAN & ADIT DETAILS

DWG NO KHPP-CV-HRT-GA-30003

GENERAL LAYOUT - PLAN

(1:20,000)

EXISTING NATIONAL HIGHWAY

PROPOSED ROAD FOR CONSTRUCTION

BRIDGE AT KONCHOLING

Flow

KHOLONG CHHU RIVER

LUNGDUCHHU

ADIT-5

Detail-3

SS-01

BEND-5

PACKAGE-2

PACKAGE-3

*RD. 16+188.469

*RD. 16+233.527

HRT-11

*RD. 14+570.738 KC-3 (START)

KC-2A (END)/KC-3 RDT.14+572.50

HRT-10

HRT-09

HRT-08

HRT-07

ADIT-3

BEND-4

33 KV DISTRIBUTION LINE

Detail-1

Detail-2

ADIT-2

BEND-1

BEND-3

CHAPLANGCHHU

*RD. 0+000 KC-1- (START)

*RD. 0+449.238 KC-1- (END)/KC-2B (START)

KC-2B (END)/KC-2A-(START) RDT. 4+403.00

*RD. 4+301.238

HRT-02

PACKAGE-1

PACKAGE-2B

*RD. 2+301.238 KC-1- (END)/KC-2B (START) RDT 2+303.00

HEADRACE TUNNEL Ø5.70m

HRT ADIT-II NEW LOCATION

BEND-2

BRIDGE

CHAPLANGCHHU NALLA WORKS ON HOLD. REFER KHPP-CV-GEN-GA-30000.5

ADIT-1

(N.T.S, ROTATED)

E- 47338.963
N- 73307.284
EL.1537.70

HRT, 5.7mØ, (HORSE SHOE)
(6.8mx6.8m D SHAPED)
231.449m LONG

E- 47560.6607
N- 73240.8094
EL.1525.403

SLOPE 1: 18.822

ADIT-2

(N.T.S, ROTATED)

E- 46384.411
N- 70408.205
EL.1505.016

(6.8mx6.8m D SHAPED)
251.42m LONG

PORTAL
E- 46482.434
N- 70630.152
EL.1502.294

E- 46469.206
N- 70600.082

SLOPE 1: 92.502

HRT, 5.7mØ, (HORSE SHOE)

E- 46488.169
N- 70589.133
EL.1502.749

E- 46490.024
N- 70606.870
EL.1502.549

ADIT-3

(N.T.S, ROTATED)

E- 49143.973
N- 68655.036
EL.1498.329

(6.8mx6.8m D SHAPED)
246.058m LONG

E-49266.843
N- 68831.604
EL.1482.531

E- 49270.731
N- 68836.147
EL.1483.203

SLOPE 1: 19.963

HRT, 5.7mØ, (HORSE SHOE)

E- 49291.468
N- 68814.468

PORTAL
E- 49288.765
N- 68853.397
EL.1486.000

ADIT-4

(N.T.S, ROTATED)

E- 49907.143
N- 65695.562
EL.1491.864

(6.8mx6.8m D SHAPED)
648.56m LONG)

PORTAL
E- 50548.375
N- 65792.821
EL.1488.00

SLOPE 1: 167.977

HRT, 5.7mØ, (HORSE SHOE)

ADIT-5

(N.T.S, ROTATED)

E- 50370.278
N- 63278.405
EL.1486.831

(6.8mx6.8m D SHAPED)
566.62m LONG

PORTAL
E- 50926.091
N- 63388.566
EL.1484.00

SLOPE 1: 200.644

HRT, 5.7mØ, (HORSE SHOE)

ADIT-6

(N.T.S, ROTATED)

E- 51087.957
N- 60062.750
EL.1480.10

HRT, 5.7mØ, (HORSE SHOE)

(6.8mx6.8m D SHAPED)
374.824m LONG)

E- 51261.821
N- 60080.236
EL.1479.381

E- 51134.099
N- 60074.188
EL.1479.834

E- 51140.039
N- 60075.042
EL.1479.800

E- 51269.291
N- 60079.754
EL.1479.075

E- 51275.894
N- 60077.929
EL.1479.037

*RD. 16+188.469
RDT

SLOPE 1: 179.170

*RD. 16+233.527
RDT

E- 51141.318
N- 60045.069

E- 51097.772
N- 60018.773
EL.1480.000

SURGE SHAFT

E- 51263.313
N- 60045.268

E- 51448.546
N- 60011.414
EL.1478.00

SLOPE 1: 179.170

REFER SEPARATE DRAWING KHPP-CV-GEN-GA-30000.4

DETAIL-1

(N.T.S, ROTATED)

PACKAGE-1 PACKAGE-2

Flow

HRT, 5.7mØ, (HORSE SHOE)

E- 46656.643
N- 71811.727
EL.1520.60

*RD. 2+301.238 KC-1- (END)/KC-2B (START) RDT 2+303.00

DETAIL-2

(N.T.S, ROTATED)

PACKAGE-2B PACKAGE-2A

Flow

HRT, 5.7mØ, (HORSE SHOE)

E- 46736.143
N- 70206.495
EL.1499.482

*RD. 4+301.238 KC-2B (END)/KC-2A-(START) RDT. 4+403.00

DETAIL-3

(N.T.S, ROTATED)

PACKAGE-2 PACKAGE-3

Flow

E- 50735.574
N- 61641.647
EL.1483.40

*RD. 14+570.738 KC-2A (END) RDT.14+572.50 KC-3 (START)

Legend:

PROJECT ROAD

PACKAGE-1 PACKAGE-2 PACKAGE-3

CONCRETE PLUG CONCRETE PLUG WITH GATE

HORZ.	HORIZONTAL
HRT	HEADRACE TUNNEL
Cx	x - BEND NUMBER
Cx - C / E / S	C - CENTER / E- End / S-START OF CURVE
ADx- C / E / S	ADx CURVE ON ADIT x - CENTER / E- End / S-START OF CURVE
*RD	UPDATED "RD" (BASED ON NEW TRANSITION DETAILS)
RDT	AS PER TENDER DOCUMENT

NOTES:

1. This drawing shows the layout plan of head race tunnel and its adits only
2. All dimensions, elevations & *rd's are in metres unless other wise specified.
3. No dimension shall be measured from the drawing only written dimensions shall be followed.
4. The length of HRT is tentative. any change at site must be immediately communicated to the designer.
5. The layout of various components shall be verified at the site before taking up the construction and discrepancy, if any, shall be communicated to project authority & consultant.
6. The drawing of layout plan of head race tunnel has been prepared based on the topographical survey received from the project authority.
7. All invert levels of HRT given in the drawing are finished levels (after concreting).
8. All invert levels and length of adit portals shall be verified at the site before taking up the construction and discrepancy, if any, shall be communicated.

1:20'000 (A1)

0 200 1000 2000 m

FOR TENDER PURPOSE ONLY

BEND-1

(N.T.S)

C1-S C1-E 1610 1710 1780 64.76° 12.37° R300.00 HRT, 5.7mØ, (HORSE SHOE) Flow

BEND-2

(N.T.S)

C2-C C2-S C2-E 1590 1540 1690 R225 94.12° 370.00 (STEEL LINED) HRT, 5.7mØ, (HORSE SHOE) Flow

BEND-3

(N.T.S)

1830 1850 1950 1980 26.18° C3-E C3-S 10.00 HRT, 5.7mØ, (HORSE SHOE) Flow

C3-C

BEND-4

(N.T.S)

C1-C C4-E C4-S C4-C 244.51 46.69° R300 1660 1680 1700 1730 HRT, 5.7mØ, (HORSE SHOE) Flow

BEND-5

(N.T.S)

C5-C C5-S C5-E 1500 1600 R300 4.112° 21.53 HRT, 5.7mØ, (HORSE SHOE) Flow

Bend Coordinates of Head Race Tunnel

Curve	Point	East [m]	North [m]	Package
Curve-1	C1-S	47195.172	72813.660	PACKAGE-1
	C1-E	47170.518	72753.917	
	C1-C	46907.144	72897.562	
Curve-2	C2-S	46119.154	70826.247	PACKAGE-2
	C2-E	46208.834	70508.894	
	C2-C	46311.662	70709.297	
Curve-3	C3-S	47738.676	69631.566	
	C3-E	47760.790	69617.568	
	C3-C	47586.790	69367.078	
Curve-4	C4-S	49397.036	68479.974	
	C4-E	49522.827	68276.579	
	C4-C	49226.099	68232.396	
Curve-5	C5-S	50058.568	64678.604	
	C5-E	50062.500	64657.440	
	C5-C	50355.297	64722.787	

APPROV.	CIVIL	MECH.	INST.	ELEC.	STRL.	ARCH.	NATURE OF REVISION & DESCRIPTION	CHECKED	DRAWN	REV.	DATE
				REVIEWED							

FILE NAME: KHPP-CV-HRT-GA-30003

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CLIENT:

KHORLOCHHU HYDRO POWER LIMITED
TRASHIYANGTSE, BHUTAN

CONSULTANT:

Tata Consulting Engineers Ltd. &
Lombardi Engineering Ltd.(JV)

PROJECT:

KHORLOCHHU HYDRO POWER PROJECT(4X150 MW), TRASHIYANGTSE, BHUTAN

TITLE:

HEAD RACE TUNNEL
PLAN & ADIT DETAILS

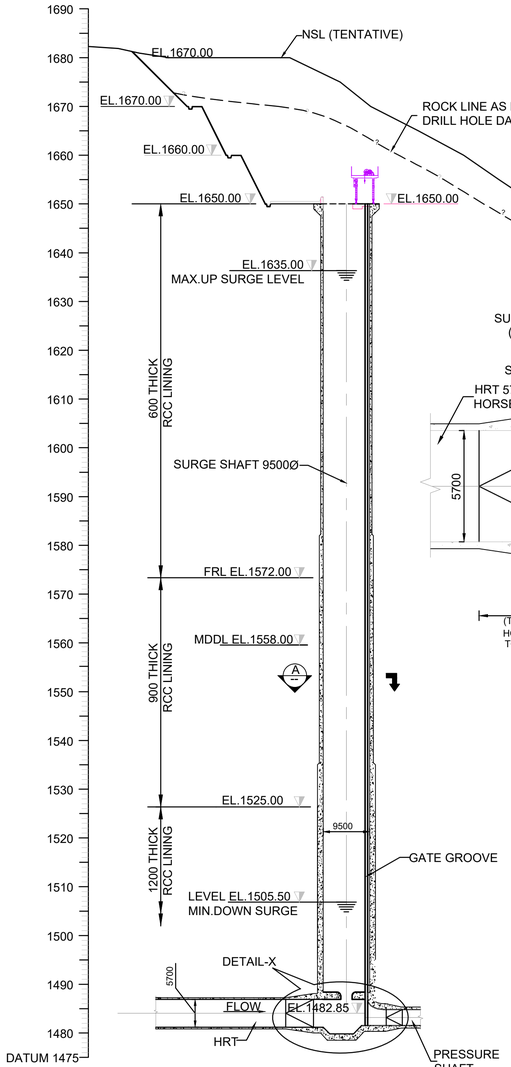
DESIGNED: RS	CHECKED: PB	RECOMMENDED:
DRAWN : ZMT	APPROVED: PLN	

DWG No: KHPP-CV-HRT-GA-30003

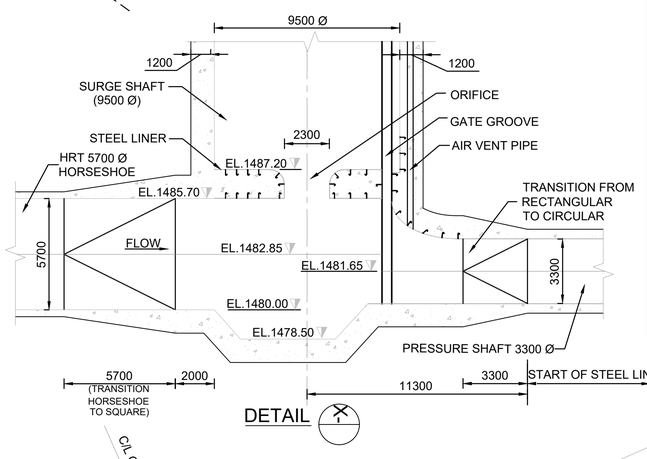
SCALE: AS SHOWN	ISSUE P1	DATE: 08-AUG-2025	ORIGINAL PRINT SIZE: A1

TITLE: SURGE SHAFT PLAN & CROSS SECTIONS

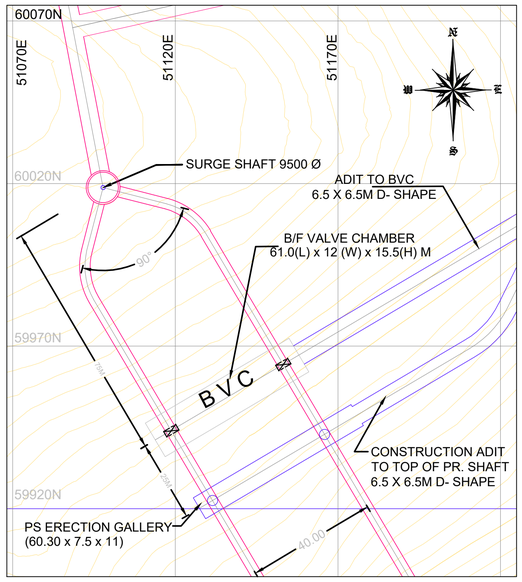
DWG NO KHPP-CV-SS-GA-30004



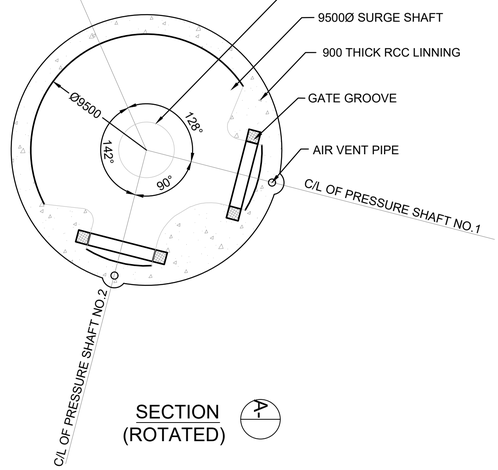
SECTION



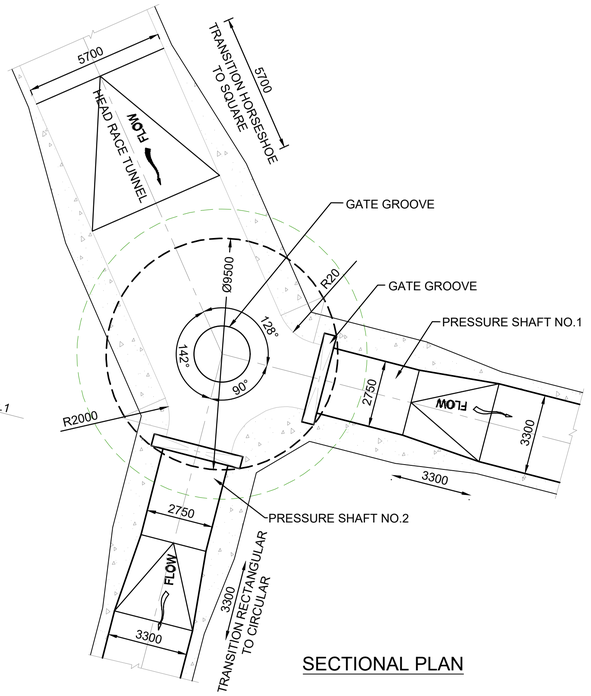
DETAIL



KEY PLAN



SECTION (ROTATED)



SECTIONAL PLAN

FOR TENDER PURPOSE ONLY

CLIENT: KHORLOCHHU HYDRO POWER LIMITED, TRASHIYANGTSE, BHUTAN

CONSULTANT: Tata Consulting Engineers Ltd. & Lombardi Engineering Ltd.(JV)

PROJECT: KHORLOCHHU HYDRO POWER PROJECT(4X150 MW), TRASHIYANGTSE, BHUTAN

TITLE: SURGE SHAFT PLAN & CROSS SECTIONS

DESIGNED: RS	CHECKED: PB	RECOMMENDED:
DRAWN : ZMT	APPROVED: PLN	
DWG No: KHPP-CV-SS-GA-30004		
SCALE: AS SHOWN	ISSUE P1	DATE: 08-AUG-2025
ORIGINAL PRINT SIZE: A1		

FILE NAME: KHPP-CV-SS-GA-30004

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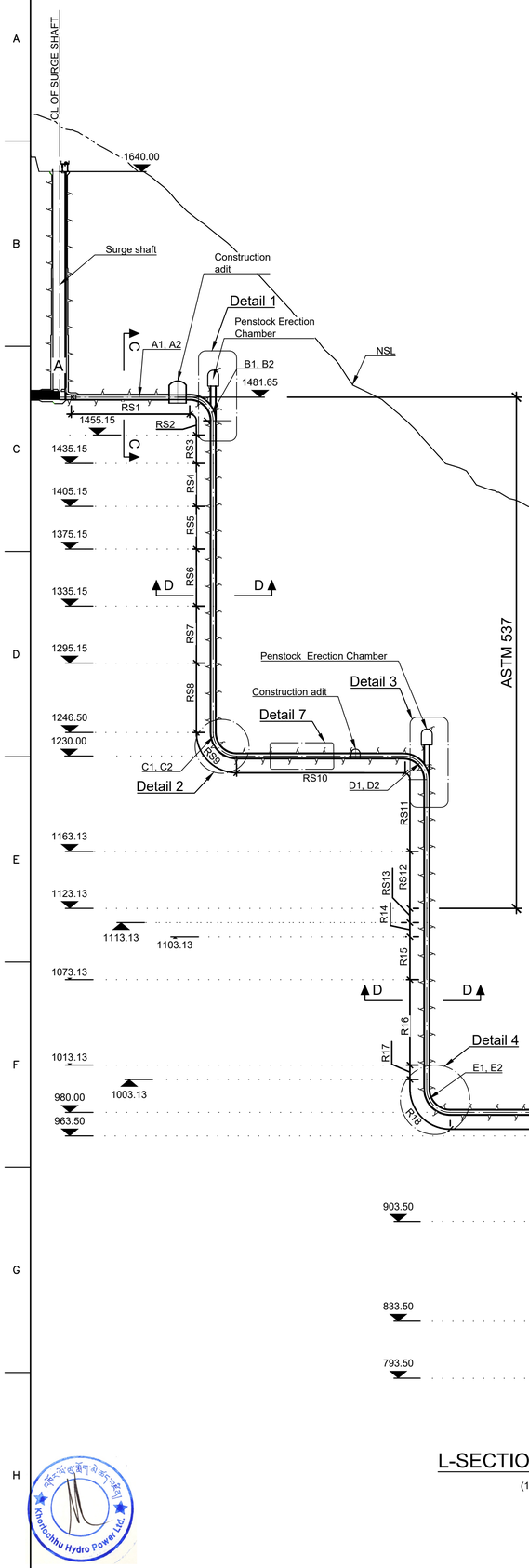
APPROV.	CIVIL	MECH.	INST.	ELEC.	STRL.	ARCH.	NATURE OF REVISION & DESCRIPTION	CHECKED	DRAWN	REV.	DATE
			REVIEWED								

Khorlochhu Hydro Power Ltd.

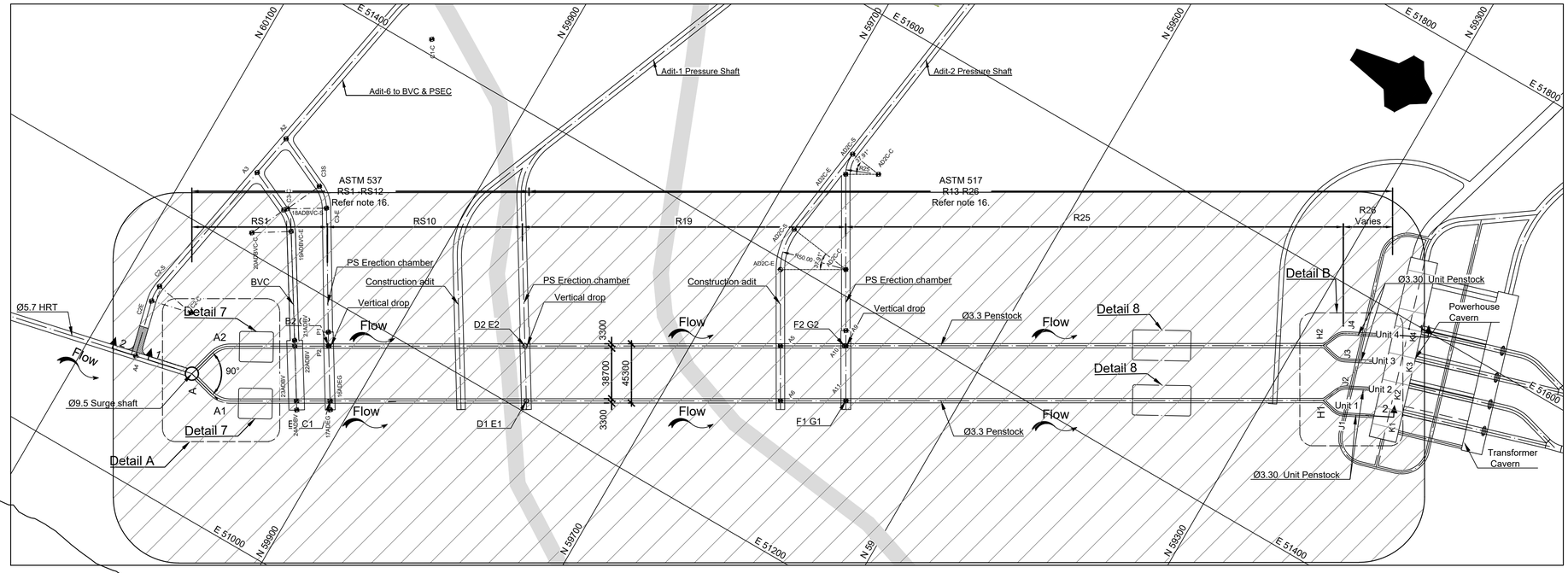
TITLE: PRESSURE SHAFT PLAN AND L/S

DWG NO KHPP-CV-PS-GA-30005



L-SECTION A-A & B-B

(1:2000)



PLAN

(1:2000)

NSL

FOR TENDER PURPOSE ONLY

CLIENT: KHORLOCHHU HYDRO POWER LIMITED, TRASHIYANGTSE, BHUTAN

CONSULTANT: Tata Consulting Engineers Ltd. & Lombardi Engineering Ltd.(JV)

PROJECT: KHORLOCHHU HYDRO POWER PROJECT(4X150 MW), TRASHIYANGTSE, BHUTAN

TITLE: PRESSURE SHAFT PLAN AND L/S

DESIGNED: RS	CHECKED: PB	RECOMMENDED:	
DRAWN : ZMT	APPROVED: PLN		
DWG No: KHPP-CV-PS-GA-30005			
SCALE: AS SHOWN	ISSUE P1	DATE: 08-AUG-2025	ORIGINAL PRINT SIZE: A1

FILE NAME: KHPP-CV-PS-GA-30005

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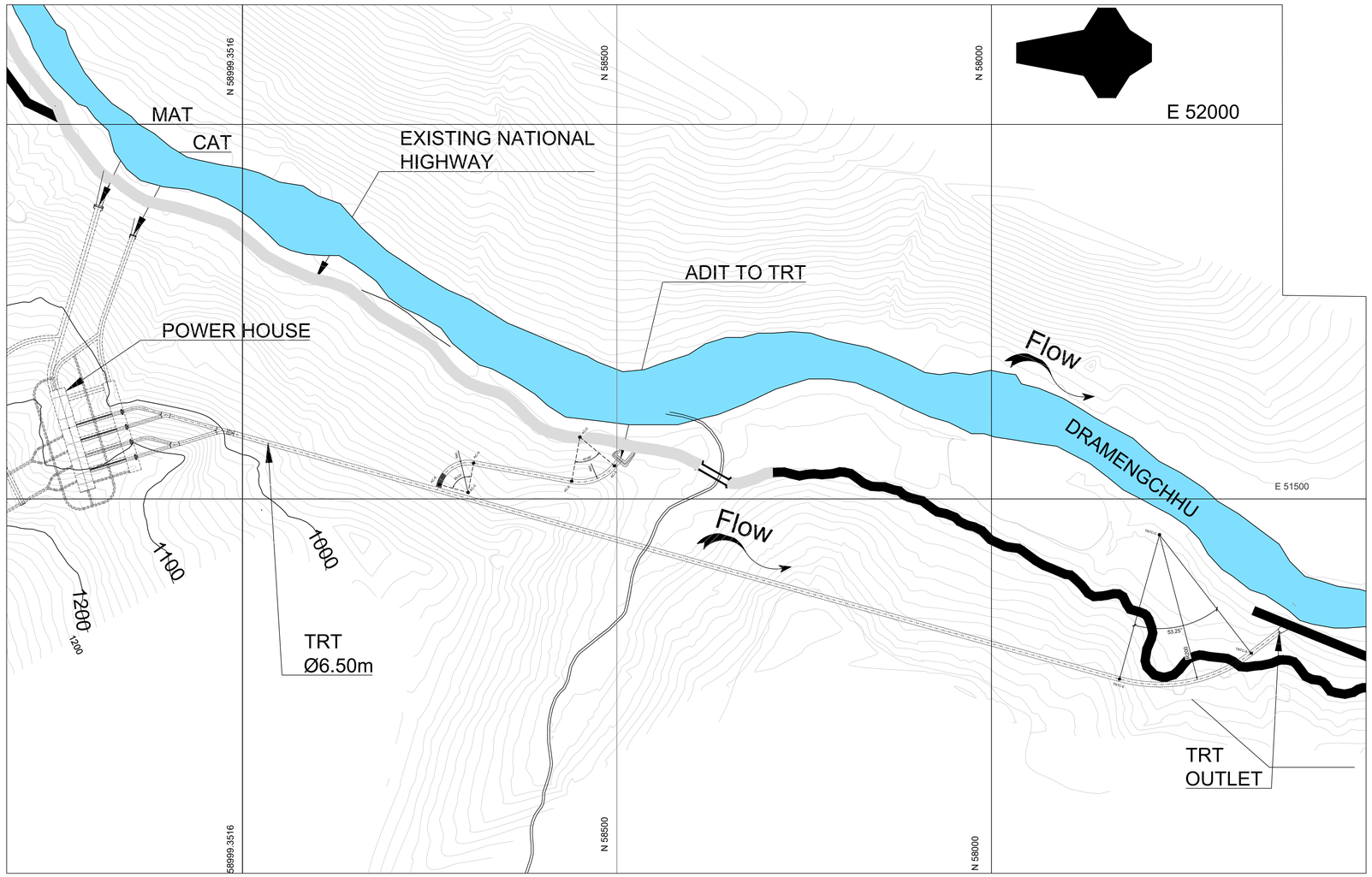
APPROV.	CIVIL	MECH.	INST.	ELEC.	STRL.	ARCH.	REVIEWED	NATURE OF REVISION & DESCRIPTION	CHECKED	DRAWN	REV.	DATE

Khorlochhu Hydro Power Ltd.

TITLE: TAILRACE TUNNEL PLAN & OUTLET PORTAL

DWG NO KHPP-CV-TRT-GA-30006



GENERAL LAYOUT - PLAN

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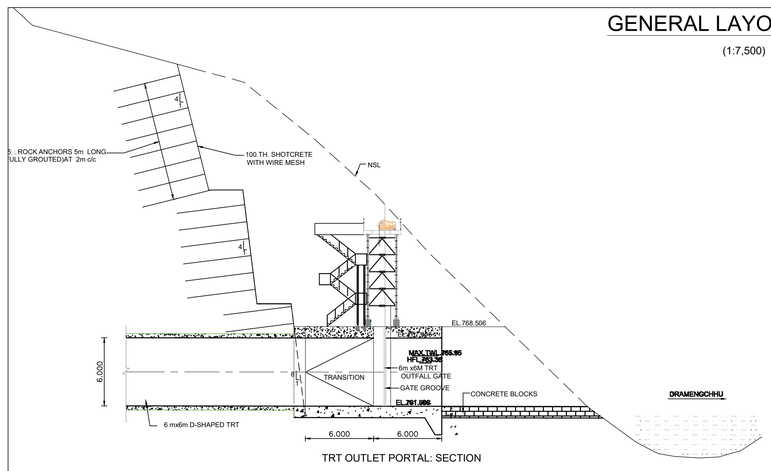
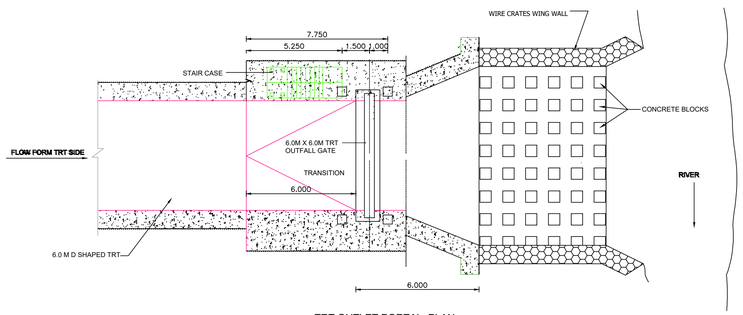


TRT OUTLET PORTAL: SECTION



TRT OUTLET PORTAL: PLAN

Legend:

- PROJECT ROAD
- PACKAGE-1
- PACKAGE-2
- PACKAGE-3
- CONCRETE PLUG
- CONCRETE PLUG WITH GATE

MAT	MAIN ACCESS TUNNEL
PS / SS / EG	PRESSURE SHAFT / SURGE SHAFT / ERECTION GALLERY
PHC / THC	POWER HOUSE CAVERN / TRANSFORMER HALL CAVERN
TRT	TAILRACE TUNNEL

FOR TENDER PURPOSE ONLY

CLIENT:
KHORLOCHHU HYDRO POWER LIMITED
TRASHIYANGTSE, BHUTAN

CONSULTANT:
Tata Consulting Engineers Ltd. &
Lombardi Engineering Ltd.(JV)

PROJECT:
KHORLOCHHU HYDRO POWER PROJECT(4X150 MW), TRASHIYANGTSE, BHUTAN

TITLE:
TAILRACE TUNNEL
PLAN & OUTLET PORTAL

DESIGNED: RS	CHECKED: PB	RECOMMENDED:
DRAWN : ZMT	APPROVED: PLN	

DWG No: KHPP-CV-TRT-GA-30006

SCALE: AS SHOWN | ISSUE: P1 | DATE: 08-AUG-2025 | ORIGINAL PRINT SIZE: A1

FILE NAME: KHPP-CV-TRT-GA-30006

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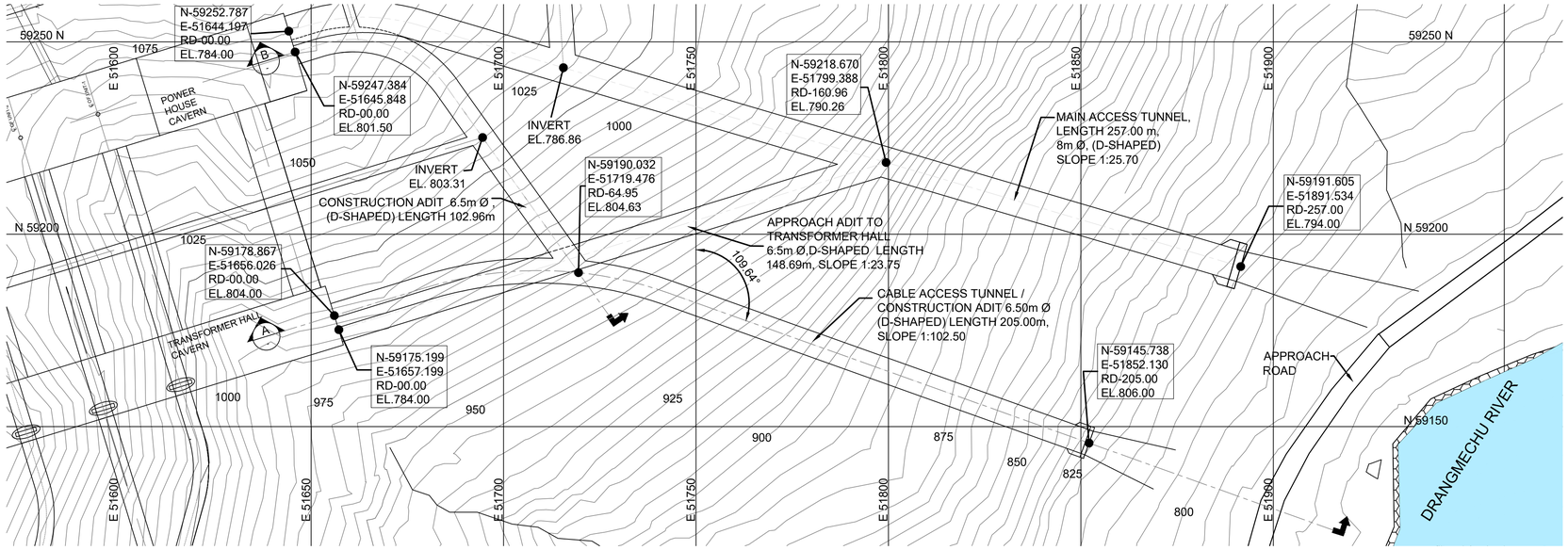
APPROV. REVIEWED	CIVIL	MECH.	INST.	ELEC.	STRL.	ARCH.	NATURE OF REVISION & DESCRIPTION	CHECKED	DRAWN	REV.	DATE

Khorlochhu Hydro Power Ltd.

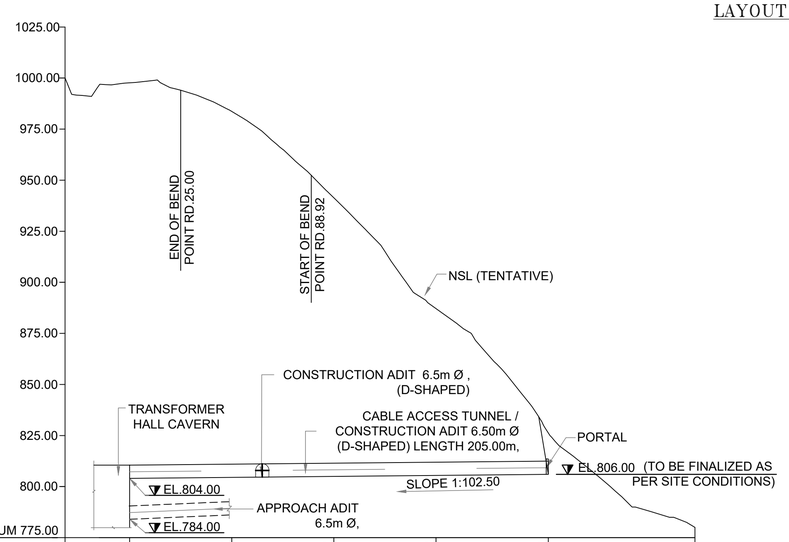
TITLE: CABLE ACCESS TUNNEL PLAN

DWG NO KHPP-CV-CAT-GA-30007



LAYOUT PLAN OF CABLE ACCESS TUNNEL (CAT)

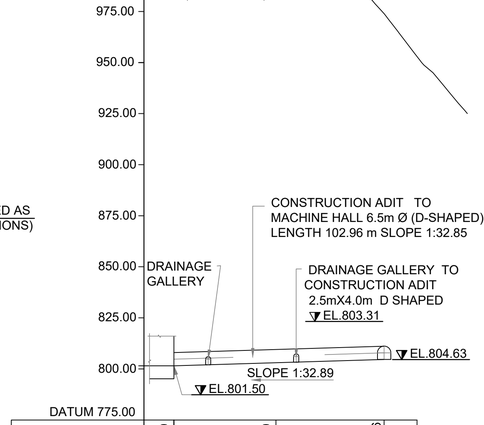
(SCALE-1)



RD(m)	00.00	50.00	100.00	150.00	205.00	
INVERT LEVEL (m)	804.00	804.49	804.98	805.46	806.00	
NSL(m)	997.68	983.66	941.33	887.15	834.70	

SECTION–A (L–SECTION)

(SCALE-2)



RD(m)	00.00	50.00	102.96
INVERT LEVEL (m)	801.50	803.02	804.63
NSL(m)	1075.35	1034.68	973.90

SECTION–B (L–SECTION)

(SCALE-2)

CABLE ACESS PORTAL ELEVATION

NOTES:

1. ALL DIMENSIONS , ELEVATIONS AND RD ARE IN METRE UNLESS OTHERWISE SPECIFIED.
2. NO DIMENSIONS/DETAILS SHALL BE MEASURED FROM THE DRAWING ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED.
3. THIS DRAWING SHOWS THE LAYOUT PLAN AND L–SECTION OF CABLE ACCESS TUNNEL ONLY.
4. THE LAYOUT SHALL BE ACTUALLY LAID ON THE GROUND AND VERIFIED BEFORE STARTING WITH EXECUTION OF WORKS.

FOR TENDER PURPOSE ONLY

CLIENT:
KHORLOCHHU HYDRO POWER LIMITED
TRASHIYANGTSE, BHUTAN

CONSULTANT:
Tata Consulting Engineers Ltd. & Lombardi Engineering Ltd.(JV)

PROJECT:
KHORLOCHHU HYDRO POWER PROJECT(4X150 MW), TRASHIYANGTSE, BHUTAN

TITLE:
CABLE ACCESS TUNNEL PLAN

DESIGNED: RS	CHECKED: PB	RECOMMENDED:
DRAWN : ZMT	APPROVED: PLN	

DWG No: KHPP–CV–CAT–GA–30007

SCALE: AS SHOWN	ISSUE P1	DATE: 08–AUG–2025

ORIGINAL PRINT SIZE: A1

FILE NAME: KHPP–CV–CAT–GA–30007

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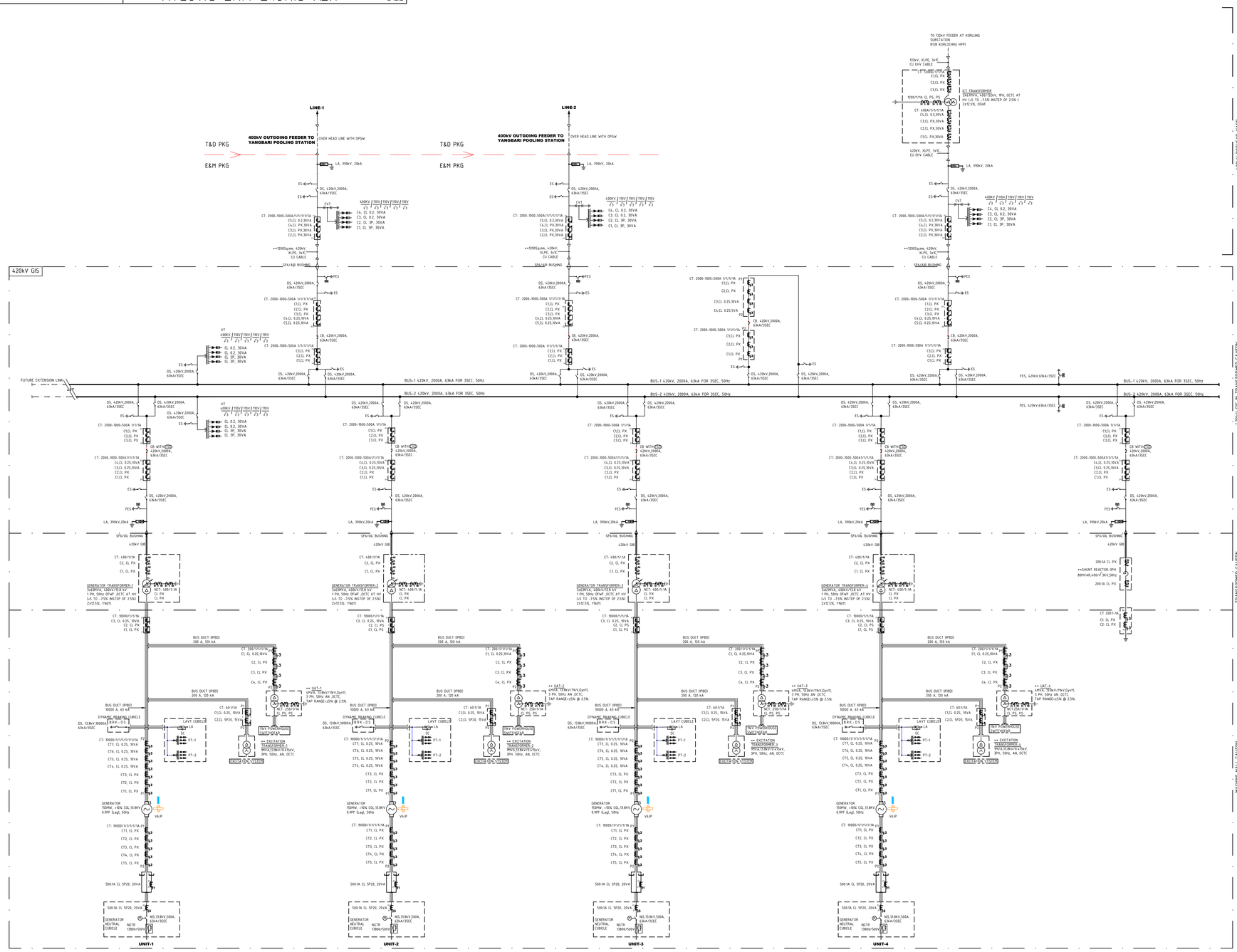
APPROV.	CIVIL	MECH.	INST.	ELEC.	STRL.	ARCH.	NATURE OF REVISION & DESCRIPTION	CHECKED	DRAWN	REV.	DATE
REVIEWED											

Khorlochhu Hydro Power Ltd.

TITLE: KEY SINGLE LINE DIAGRAM

DWG NO KHPP-EL-PH-SLD-4006-AU-40001



LEGEND

- GENERATOR (3PH)
- THREE PHASE TWO WINDING TRANSFORMER
- SINGLE PHASE TWO WINDING TRANSFORMER
- CIRCUIT BREAKER
- DISCONNECTION SWITCH (ISOLATOR) (MOTOR OPERATED)
- EARTH SWITCH (MOTOR OPERATED)
- FAST ACTING EARTH SWITCH (MOTOR OPERATED)
- CABLE
- POTENTIAL TRANSFORMER
- LIGHTNING ARRESTER
- CURRENT TRANSFORMER
- BUSHING CURRENT TRANSFORMER
- ISOLATED PHASE BUSDUCT (IPB)
- LIGHTNING ARRESTOR (LA) & SURGE CAPACITOR (SC)
- NEUTRAL GROUNDING TRANSFORMER(NGT)
- CAPACITIVE VOLTAGE TRANSFORMER
- SF6/OIL BUSHING
- SF6/AIR BUSHING
- CABLE SEALING END
- REACTOR
- SHUNT REACTOR
- EARTH SWITCH (MANUAL OPERATION)
- EARTH CONNECTION
- INTER CONNECTING TRANSFORMER (ICT)
- MOTORISED NEUTRAL ISOLATOR

NOTES

1. THIS DRAWING REPRESENT THE MAIN SINGLE LINE DIAGRAM
2. THE RATINGS INDICATED ARE MINIMUM TO BE CONSIDERED AND IT WILL BE FINALLIZED DURING DETAIL ENGINEERING.
3. TARIFF METERING WILL BE CONSIDERED AS PER CEA REQUIREMENTS.
4. RATING / QUANTITY OF BUS SHUNT REACTOR SHOWN IN THE DRAWING AT 400KV GIS IS INDICATIVE MINIMUM ONLY. HOWEVER, REQUIREMENT SHALL BE DECIDED BASED ON GRID STUDIES.
5. '**' DETAILS SHALL BE FINALISED DURING DETAILED ENGINEERING.
6. AUTO/MANUAL OPERATION, SYNCHRONISATION, DG PARALLEL OPERATIONS, NECESSARY INTERLOCKS ETC TO BE CONSIDERED FOR GRID / UNITS / INHOUSE POWER DISTRIBUTIONS FOR LOCAL AS WELL AS REMOTE OPERATIONS.
7. SAT TRANSFORMERS SHALL BE SUITABLE FOR 2X100% LOAD RATING.
8. CIRCUIT BREAKERS OF 400KV AND ABOVE VOLTAGE CLASS SHALL BE PROVIDED WITH PRE-INSERTION RESISTORS (PIR) FOR CONTROLLING SWITCHING OVERVOLTAGE ON LINES OF LENGTH MORE THAN 200km.
9. CIRCUIT BREAKERS OF 400KV AND ABOVE VOLTAGE CLASS SHALL BE PROVIDED WITH CONTROLLED SWITCHING DEVICES (CSD) AS A TOOL FOR MINIMIZING SWITCHING TRANSIENTS AND INRUSH CURRENTS IN 400KV AND ABOVE VOLTAGE CLASS TRANSFORMERS AND REACTORS .

ABBREVIATION

NGR	NEUTRAL GROUNDING RESISTOR
NGT	NEUTRAL GROUNDING TRANSFORMER
IPB	ISOLATED PHASE BUSDUCT
GIB	GAS INSULATED BUSDUCT
GT/GSUT	GENERATOR STEP UP TRANSFORMER
GIS	GAS INSULATED SWITCHGEAR
ES	EARTH SWITCH
SC	SURGE CAPACITOR
CB	CIRCUIT BREAKER
AVR	AUTOMATIC VOLTAGE REGULATOR
LAVT	LIGHTNING ARRESTOR VOLTAGE TRANSFORMER
SAT	STATION AUXILIARY TRANSFORMER
OCTC	OFF CIRCUIT TAP CHANGER
CSD	CONTROLLED SWITCHING DEVICE

FOR TENDER PURPOSE

CLIENT: KHORLOCHHU HYDRO POWER LIMITED, TRASHIYANGTSE, BHUTAN

CONSULTANT: Tata Consulting Engineers Ltd. & Lombardi Engineering Ltd.(JV)

PROJECT: KHORLOCHHU HYDRO POWER PROJECT(4X150 MW), TRASHIYANGTSE, BHUTAN

TITLE: KEY SINGLE LINE DIAGRAM

DESIGNED: JC / RKR	CHECKED: LGC	RECOMMENDED:
DRAWN : ZMT	APPROVED: PLN	

DWG No: KHPP-EL-PH-SLD-4006-AU-40001

SCALE: AS SHOWN	ISSUE P1	DATE: 20-JUN-2025	ORIGINAL PRINT SIZE: A1

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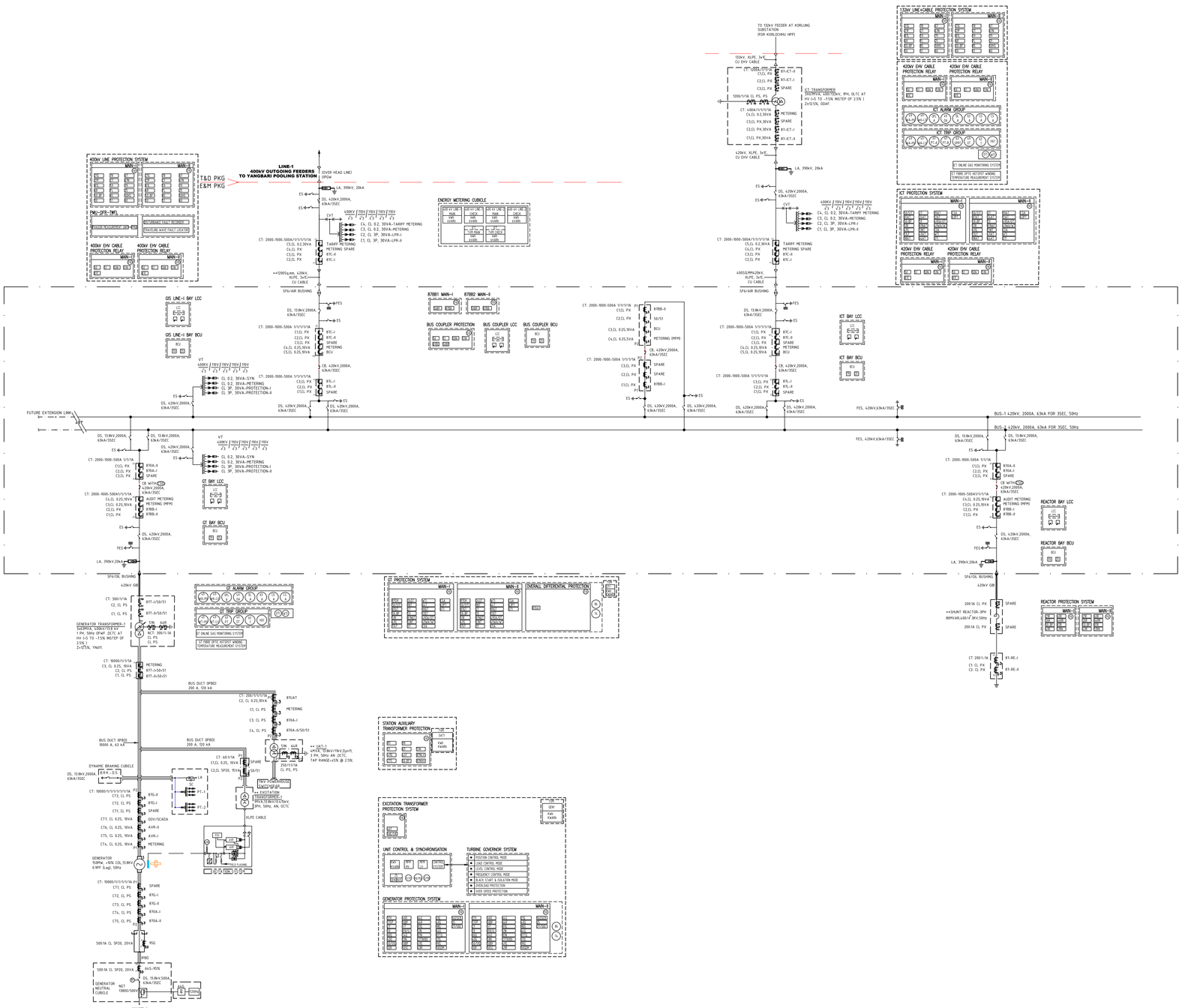
APPROV.	CIVIL	MECH.	INST.	ELEC.	STRL.	ARCH.	NATURE OF REVISION & DESCRIPTION	CHECKED	DRAWN	REV.	DATE
REVIEWED											

Khorlochhu Hydro Power Ltd.

TITLE: METERING AND PROTECTION SYSTEM SINGLE LINE DIAGRAM

DWG NO KHPP-EL-PH-SLD-4006-AU-40002



PROTECTION SYSTEM LEGEND TABLE			
ANSI CODE	**GENERATOR PROTECTION DESCRIPTION**		**ICT PROTECTION DESCRIPTION**
51V	51V -OVERCURRENT PROTECTION WITH VOLTAGE CONTROL	50/51T	INSTANTANEOUS AND TIME-OVERCURRENT PROTECTION
51SP G1	51SP- INSTANTANEOUS OR TIME-DELAYED OVERCURRENT PROTECTION	87AT	TRANSFORMER DIFFERENTIAL PROTECTION
60G1	VOLTAGE BALANCE PROTECTION	50-BF	BREAKER FAILURE PROTECTION
40G	LOSS OF EXCITATION PROBLEM	51R	TIME OVERCURRENT PROTECTION
FR	FAULT RECORDER	49S	THERMAL OVERLOAD PROTECTION
50/51G	INSTANTANEOUS OVERCURRENT PROTECTION/TIME-OVERCURRENT PROTECTION	51LF	TIME OVERCURRENT PROTECTION SPECIFICALLY FOR LOW-FREQUENCY APPLICATIONS
32R	REVERSE POWER PROTECTION	98AT	TRANSFORMER BUSHING INSULATION
46G	NEGATIVE PHASE SEQUENCE CURRENT PROTECTION.	27	UNDER VOLTAGE PROTECTION
50BF	BREAKER FAILURE PROTECTION	24GT	VOLT PER HERTZ / OVER FLUXING PROTECTION
47	NEGATIVE SEQUENCE VOLTAGE PROTECTION	59	OVER VOLTAGE PROTECTION
81O/U	UNDER/OVER FREQUENCY PROTECTION	87NAT	RESTRICTED EARTH FAULT PROTECTION
24G	OVEREXCITATION PROTECTION	51NT	TIME OVERCURRENT PROTECTION FOR THE NEUTRAL CIRCUIT
59N	NEUTRAL OVERVOLTAGE PROTECTION	49AT	THERMAL OVERLOAD PROTECTION
27	UNDER VOLTAGE PROTECTION	64AT	GROUND FAULT PROTECTION.
59	OVER VOLTAGE PROTECTION	99AT	OVER-FLUXING PROTECTION
505C	SHORT-CIRCUIT PROTECTION	51AT	BACK- UP NON-DIRECTIONAL OVER-CURRENT PROTECTION IN ALL PHASES ON HV SIDE OF TRANSFORMER
64S -95%	64S- 95% STATOR GROUND FAULT PROTECTION	49OA/OT	OIL TEMPERATURE ALARM/OIL TEMPERATURE TRIP
64R	ROTOR EARTH FAULT PROTECTION	49WA/WT	WINDING TEMPERATURE ALARM/WINDING TEMPERATURE TRIP
87G	87G- GENERATOR DIFFERENTIAL PROTECTION	COA	COOLER TROUBLE ALARM RELAY
51N	OVERCURRENT GROUND FAULT PROTECTION	CSA	COOLER SUPPLY FAILURE ALARM
87N	GROUND DIFFERENTIAL PROTECTION	63PT	PRESSURE RELIEF DEVICE TRIP
27TN100	THIRD HARMONIC UNDER-VOLTAGE PROTECTION	OTI	OIL TEMPERATURE INDICATOR
49S	STATOR THERMAL OVERLOAD PROTECTION	WTI	WINDING TEMPERATURE INDICATOR
49R	ROTOR THERMAL OVERLOAD PROTECTION		**EXCITATION PROTECTION DESCRIPTION**
21G	GENERATOR BACKUP IMPEDENCE PROTECTION	64E	RESTRICTED EARTH FAULT PROTECTION FOR EXCITATION TRANSFORMER
40G	LOSS OF FIELD (EXCITATION) PROTECTION	49T	TRANSFORMER WINDING TEMP. RELAY
98G	POLE SLIPPING PROTECTION	50-BF	BREAKER FAILURE PROTECTION
64G	STANDBY STATOR EARTH FAULT PROTECTION	50E/51E	INST. AND TIME DELAY OVERCURRENT PROTECTION FOR EXCITATION TRANSFORMER
87TG	INTER-TURN FAULT PROTECTION	51NE	BACK UP EARTH FAULT PROTECTION
37G	LOW-FORWARD POWER PROTECTION		**SAT PROTECTION RELAY DESCRIPTION**
99G	OVER-FLUXING PROTECTION FOR GENERATOR	87	DIFFERENTIAL CURRENT PROTECTION
50GDM	ACCIDENTAL BACK ENERGISATION PROTECTION	87NLV	RESTRICTED EARTH FAULT PROTECTION FOR LV WINDING
50ZGCB	GENERATOR CIRCUIT BREAKER FAILURE PROTECTION	87NHV	RESTRICTED EARTH FAULT PROTECTION FOR HV WINDING
25	SYNCHRONISING CHECK RELAY	51	UNDER VOLTAGE RELAY D91:F101
27/50G	DEAD MACHINE PROTECTION	51N	BACK-UP EARTH-FAULT PROTECTION
50-BF	BREAKER FAILURE PROTECTION	99	OVER-FLUXING PROTECTION
86	MASTER TRIP RELAY	63	BUCHHOLZ PROTECTION
74	TRIP CIRCUIT SUPERVISION	49T	WINDING TEMPERATURE HIGH
	GT PROTECTION DESCRIPTION	49Q	OIL TEMPERATURE HIGH
87OA	OVERALL DIFFERENTIAL PROTECTION	50-BF	BREAKER FAILURE PROTECTION
50/51T	INSTANTANEOUS AND TIME-OVERCURRENT PROTECTION	27S	UNDER VOLTAGE RELAY
87GT	TRANSFORMER DIFFERENTIAL PROTECTION RELAY		**REACTOR BAY PROTECTION DESCRIPTION**
50-BF	BREAKER FAILURE PROTECTION	21 R	REACTOR DISTANCE PROTECTION
51R	TIME OVERCURRENT PROTECTION	26R	REACTOR OIL TEMPERATURE RELAY
49S	THERMAL OVERLOAD PROTECTION	50-BF	BREAKER FAILURE PROTECTION
51LF	TIME OVERCURRENT PROTECTION SPECIFICALLY FOR LOW-FREQUENCY APPLICATIONS	49R	REACTOR WINDING TEMPERATURE RELAY
24GT	VOLT PER HERTZ / OVER FLUXING PROTECTION	63R	REACTOR BUCHHOLZ RELAY
98T	TRANSFORMER BUSHING INSULATION	64RR	RESTRICTED E/F PROTECTION FOR BUS REACTOR
27	UNDER VOLTAGE PROTECTION	87R	DIFFERENTIAL PROTECTION FOR BUS REACTOR
59	OVER VOLTAGE PROTECTION	51RN	DIFFERENTIAL O/C & E/F PROTECTION
87NGT	RESTRICTED EARTH FAULT PROTECTION FOR GENERATOR TRANSFORMER		**OVER HEAD LINE PROTECTION DESCRIPTION**
51NT	TIME OVERCURRENT PROTECTION FOR THE NEUTRAL CIRCUIT	21G	GROUND DISTANCE
37	LOSS OF FIELD PROTECTION	21P	PHASE DISTANCE
49GT	THERMAL OVERLOAD PROTECTION, SPECIFICALLY FOR THE END TURNS OF STATOR WINDINGS	87L	LINE DIFFERENTIAL PROTECTION
64T	GROUND FAULT PROTECTION.	68	BLOCKING RELAY / POWER SWING BLOCKING
99GT	OVER-FLUXING PROTECTION FOR GENERATOR TRANSFORMER	50-BF	LINE BREAKER FAILURE
51GT	BACK- UP NON-DIRECTIONAL OVER-CURRENT PROTECTION IN ALL PHASES ON HV SIDE OF GENERATOR TRANSFORMER	78	PHASE ANGLE MEASURING OR OUT-OF-STEP PROTECTION
49OA/OT	OIL TEMPERATURE ALARM/OIL TEMPERATURE TRIP	27	UNDER VOLTAGE PROTECTION
49WA/WT	WINDING TEMPERATURE ALARM/WINDING TEMPERATURE TRIP	59	OVER VOLTAGE PROTECTION
COA	COOLER TROUBLE ALARM RELAY	FL	FAULT LOCATOR
CSA	COOLER SUPPLY FAILURE ALARM	FR	FAULT RECORDER
63PT	PRESSURE RELIEF DEVICE TRIP	85	CARRIER OR PILOT-WIRE PROTECTION
OTI	OIL TEMPERATURE INDICATOR	67	DIRECTIONAL OVERCURRENT PROTECTION
WTI	WINDING TEMPERATURE INDICATOR	67N	NEUTRAL DIRECTIONAL OVERCURRENT PROTECTION
	BUSBAR & BUSCOUPLER PROTECTION DESCRIPTION	79	AUTO RECLOSER
87BB	BUSBAR DIFFERENTIAL PROTECTION	25	SYNCHRONISM-CHECK
50	INTANTANEOUS OVERCURRENT	50HS	HIGH-SPEED OVER CURRENT
51	TIME-DELAYED OVERCURRENT		**132/400KV XLPE , EHV CABLE PROTECTION DESCRIPTION**
50N	INTANTANEOUS EARTH FAULT	87C	CABLE DIFFERENTIAL PROTECTION
51N	TIME-DELAYED OVERCURRENT	50	INTANTANEOUS OVERCURRENT
50-BF	LINE BREAKER FAILURE	51	TIME-DELAYED OVERCURRENT
		50N	INTANTANEOUS EARTH FAULT
LCC	LOCAL CONTROL CABINET	51N	TIME-DELAYED OVERCURRENT

NOTES :–

1. ALL THE RATINGS INDICATED ARE MINIMUM, WILL BE FINALLIZED DURING DETAIL ENGINEERING.
2. TARIFF METERING WILL BE CONSIDERED AS PER CEA REQUIREMENTS.
3. RATING / QUANTITY OF BUS SHUNT REACTOR SHOWN IN THE DRAWING AT 400KV GIS IS INDICATIVE MINIMUM ONLY. HOWEVER, REQUIREMENT SHALL BE DECIDED BASED ON GRID STUDIES.
4. DEDICATED CT OR PT (NOT COMBINED WITH OTHER CORES) SHALL BE CONSIDERED FOR TARIFF METERING PURPOSE, IF REQUIRED.
5. ## DETAILS WILL BE AS PER OEM STANDARD.
6. '**' DETAILS SHALL BE FINALISED DURING DETAILED ENGINEERING.
7. PROTECTION & METERING FOR LINE–2 WILL BE SAME AS LINE–1.
8. PROTECTION & METERING FOR UNIT–2, UNIT–3 & UNIT–4 WILL BE SAME AS UNIT–1.
9. FAULT RECORDER TO BE CONSIDER IN EACH NUMERICAL RELAY.

ABBREVIATION

NGR	NEUTRAL GROUNDING RESISTOR
IPBD	ISOLATED PHASE BUSDUCT
GIB	GAS INSULATED BUSDUCT
GT/GSUT	GENERATOR STEP UP TRANSFORMER
PLC	PROGRAMMABLE LOGIC CONTROLLER
NO	NORMALLY OPEN
NC	NORMALLY CLOSE
LR	LOADING REGISTER
SEE	STATIC EXCITATION EQUIPMENT
UAT	UNIT AUXILIARY TRANSFORMER
UAB	UNIT AUXILIARY BOARD
I/L	INTERLOCK
LAVT	LIGHTNING ARRESTOR VOLTAGE TRANSFORMER
SPBD	SEGREGATED PHASE BUSDUCT OCTC OFF CIRCUIT TAP CHANGER
DS	DISCONNECTOR SWITCH
ES	EARTH SWITCH
CB	CIRCUIT BREAKER
ES	HIGH SPEED EARTH SWITCH
SA	SURGE ARRESTOR
AVR	AUTOMATIC VOLTAGE REGULATOR
NGT	NGR NEUTRAL GROUNDING RESISTOR
SAT	STATION AUXILIARY TRANSFORMER
SAB	STATION AUXILIARY BOARD

APPROV.	CIVIL	MECH.	INST.	ELEC.	STRL.	ARCH.	NATURE OF REVISION & DESCRIPTION	CHECKED	DRAWN	REV.	DATE
REVIEWED											

FILE NAME: KHPP–EL–PH–SLD–4006–AU–40002

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FOR TENDER PURPOSE

CLIENT:
KHORLOCHHU HYDRO POWER LIMITED
TRASHIYANGTSE, BHUTAN

CONSULTANT:
Tata Consulting Engineers Ltd. &
Lombardi Engineering Ltd.(JV)

PROJECT:
KHORLOCHHU HYDRO POWER PROJECT(4X150 MW), TRASHIYANGTSE, BHUTAN

TITLE:
METERING AND PROTECTION SYSTEM
SINGLE LINE DIAGRAM

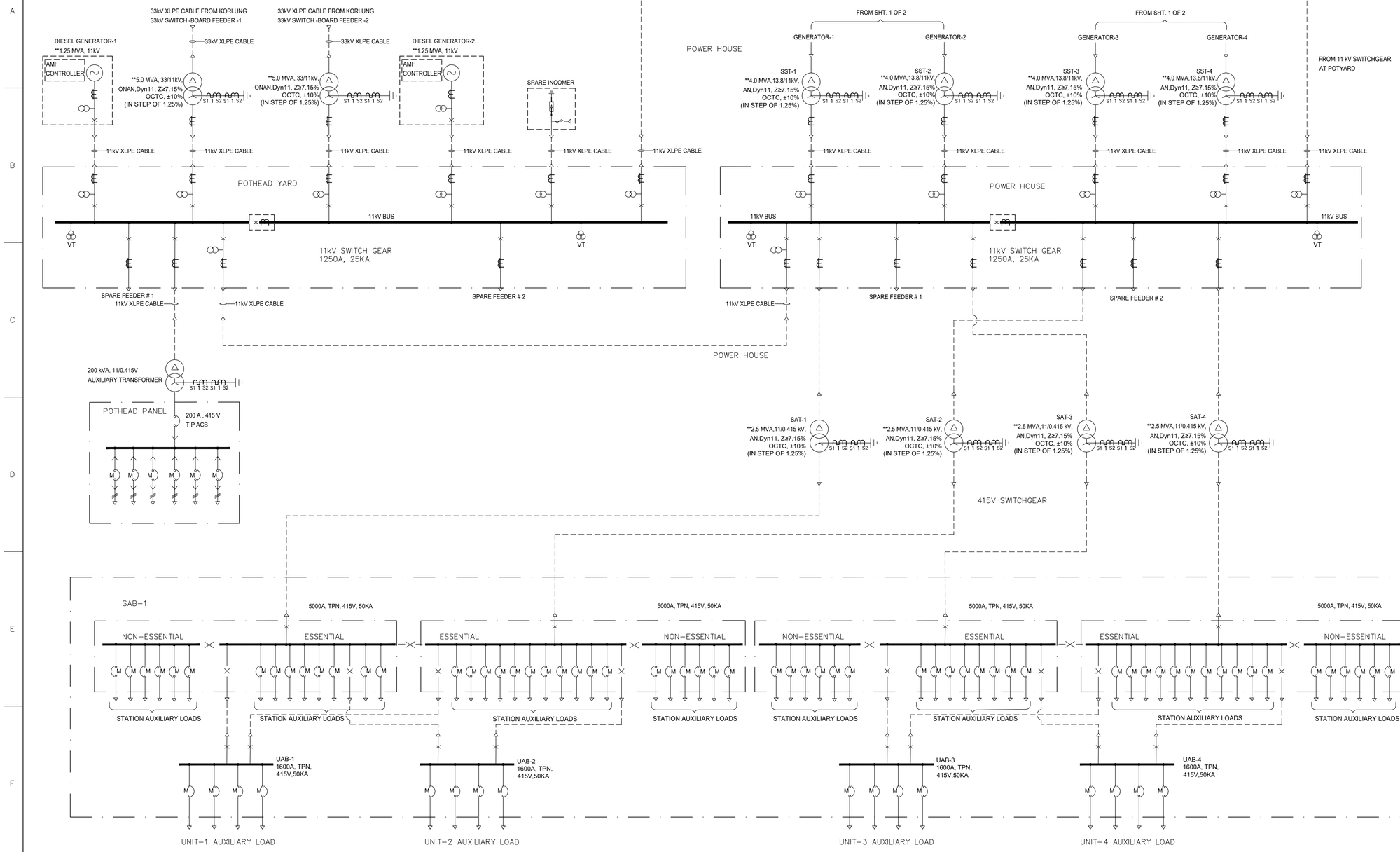
DESIGNED: JC / RKR	CHECKED: LGC	RECOMMENDED:
DRAWN : ZMT	APPROVED: PLN	

DWG No: KHPP–EL–PH–SLD–4006–AU–40002

SCALE: AS SHOWN	ISSUE P1	DATE: 20–JUN–2025	ORIGINAL PRINT SIZE: A1

TITLE: MV & LV DISTRIBUTION SINGLE LINE DIAGRAM

DWG NO KHPP-EL-PH-SLD-4006-AU-40003



NOTES :-

1. THE RATINGS SHOWN IN THE DRAWING IS MINIMUM INDICATIVE. HOWEVER, IT SHALL BE MATCHED AS PER SYSTEM REQUIREMENT DURING DETAILED ENGINEERING.
2. AUXILIARY POWER DISTRIBUTION SHOWN IN THE DRAWING IS INDICATIVE. IT SHALL BE CONSIDERED AFTER FINALIZING THE LOADS AS REQUIRED.
3. LV SWITCHGEARS SHALL BE OF FULLY DRAWOUT TYPE WITH LOTO FACILITIES.
4. ADDITIONAL DETAILS REFER TENDER SPECIFICATION.
5. ALL TRANSFORMER AND DG RATINGS MENTIONED HEREIN ARE TENTATIVE. THE VENDOR SHALL CONFIRM THE APPROPRIATE RATINGS BASED ON THE LOAD LIST DURING THE SUBMISSION OF THEIR OFFERS.
6. '**' DETAILS SHALL BE FINALISED DURING DETAILED ENGINEERING.

SYMBOL	DESCRIPTION
	3 PHASE 415V, FEEDERS
A	415V AIR CIRCUIT BREAKER
M	415V MOULDED CASE CIRCUIT BREAKER
	CONNECTION THROUGH XLPE CABLE

ABBREVIATION

AMF	AUTOMATIC MAIN FAILURE
SAT	STATION AUXILIARY TRANSFORMER
SST	STATION SERVICE TRANSFORMER
DG	DIESEL GENERATOR

FOR TENDER PURPOSE

CLIENT: KHORLOCHHU HYDRO POWER LIMITED, TRASHIYANGTSE, BHUTAN

CONSULTANT: Tata Consulting Engineers Ltd. & Lombardi Engineering Ltd.(JV)

PROJECT: KHORLOCHHU HYDRO POWER PROJECT(4X150 MW), TRASHIYANGTSE, BHUTAN

TITLE: MV & LV DISTRIBUTION SINGLE LINE DIAGRAM

DESIGNED: JC / RKR	CHECKED: LGC	RECOMMENDED:
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DWG No: KHPP-EL-PH-SLD-4006-AU-40003

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FILE NAME: KHPP-EL-PH-SLD-4006-AU-40003

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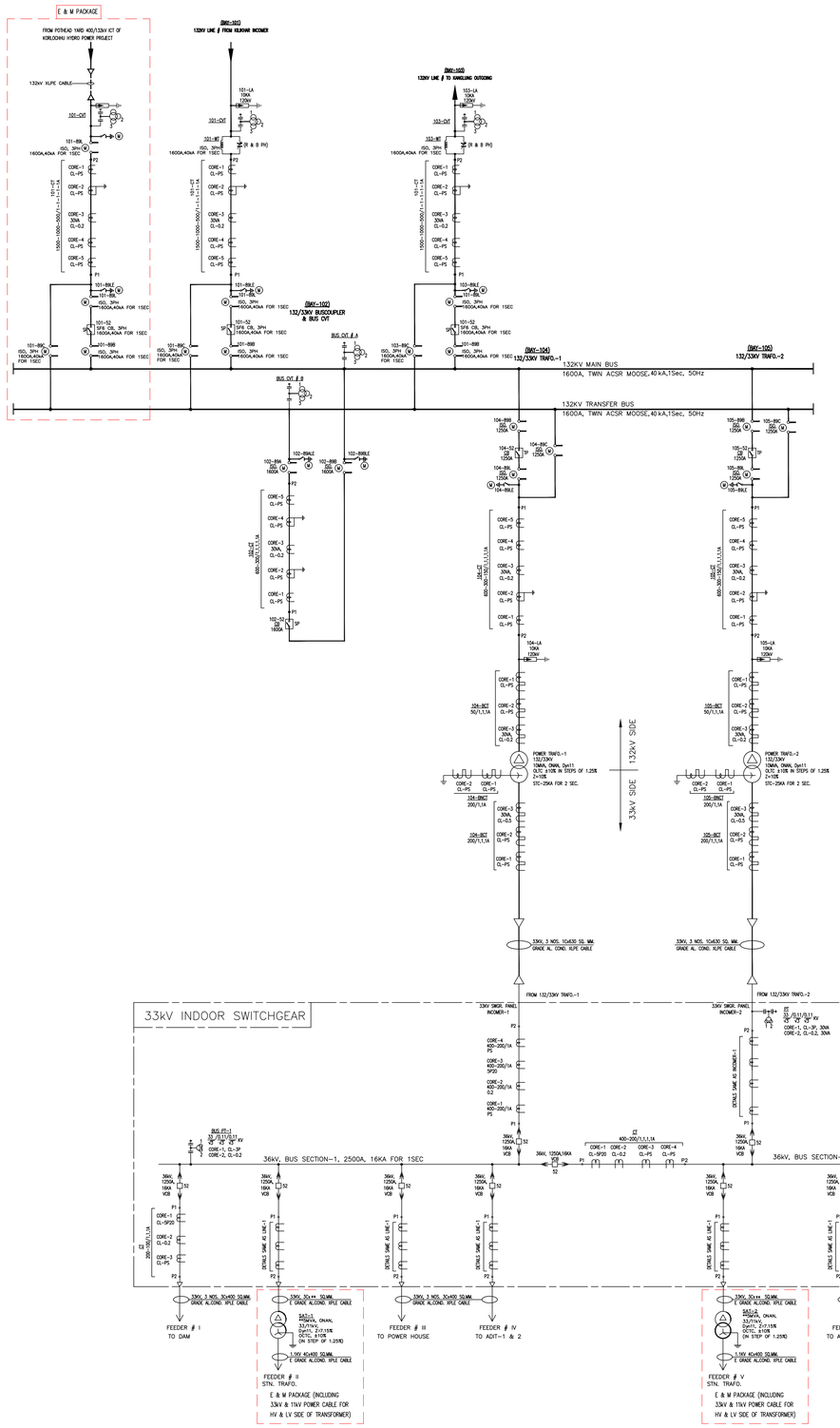
APPROV.	REVIEWED: CIVIL	MECH.	INST.	ELEC.	STRL.	ARCH.	NATURE OF REVISION & DESCRIPTION	CHECKED	DRAWN	REV.	DATE

Khorlochhu Hydro Power Ltd.

TITLE: 132KV SWITCHYARD SINGLE LINE DIAGRAM

DWG NO KHPP-EL-PH-SLD-4006-AU-40004



132kV CT CORE DETAILS (INCOMER & TRANSFORMER)
CT RATIO: 600-300-150/1,1,1,1,1A

CORE	CT RATIO	PURPOSE	OUTPUT BURDEN (VA)	ACCURACY CLASS AS PER IEC: 44-I	MIN. KNEE PT. VOLTAGE (Vk)	MAX. CT SEC. WDG. RESISTANCE (ohms)	MAX. CT EXCITATION CURRENT AT Vk/4 (IN mA)
1	600-300-150/1A	PROTECTION		PS	600 300 150	4/2/1	15/30/60
2	600-300-150/1A	PROTECTION		PS	600 300 150	4/2/1	15/30/60
3	600-300-150/1A	METERING	30	0.2			
4	600-300-150/1A	PROTECTION		PS	600 300 150	4/2/1	15/30/60
5	600-300-150/1A	PROTECTION		PS	600 300 150	4/2/1	15/30/60

132kV CT CORE DETAILS (BUSCOUPLER)
CT RATIO: 600-300/1,1,1,1,1A

CORE	CT RATIO	PURPOSE	OUTPUT BURDEN (VA)	ACCURACY CLASS AS PER IEC: 44-I	MIN. KNEE PT. VOLTAGE (Vk)	MAX. CT SEC. WDG. RESISTANCE (ohms)	MAX. CT EXCITATION CURRENT AT Vk/4 (IN mA)
1	600-300/1A	PROTECTION		PS	600 300	4/2	30/60
2	600-300/1A	PROTECTION		PS	600 300	4/2	30/60
3	600-300/1A	METERING	30	0.2			
4	600-300/1A	PROTECTION		PS	600 300	4/2	30/60
5	600-300/1A	PROTECTION		PS	600 300	4/2	30/60

132/33kV, 10MVA TRANSFORMER, BUSHING CT CORE DETAILS

CORE	CT RATIO	PURPOSE	OUTPUT BURDEN (VA)	ACCURACY CLASS AS PER IEC:185	MIN. KNEE PT. VOLTAGE (Vk)	MAX. CT SEC. WDG. RESISTANCE (ohms)	MAX. CT EXCITATION CURRENT AT Vk/4 (IN mA)
66/33kV (HV)							
1	50/1A	PROTECTION		PS	1000V	1.5	100
2	50/1A	PROTECTION		PS	1000V	1.5	100
3	50/1A	METERING	30	0.2			
132/33kV (LV)							
1	200/1A	PROTECTION		PS	600V	1.5	100
2	200/1A	PROTECTION		PS	600V	1.5	100
3	200/1A	METERING	30	0.5			
132/33kV NEUTRAL (LV)							
1	200/1A	PROTECTION		PS	600V	1.5	100
2	200/1A	PROTECTION		PS	600V	1.5	100

132kV EQUIPMENT

Sl.No.	LEGEND	DESCRIPTION	QTY.
01		145kV,1250A,40KA, 3PH FOR 1 SEC., HCB ISOLATOR ISOLATOR (MOTOR OPERATED)	8 SET
02		145kV,1250A,40KA, 3PH FOR 1 SEC., HCB ISOLATOR WITH 1 EARTH SWITCH (MOTOR OPERATED)	04 SET
03		145kV,1600A,40KA, 3PH FOR 1 SEC., HCB ISOLATOR WITH 1 EARTH SWITCH (MOTOR OPERATED)	02 SET
04	SP	145kV, 31.5kA FOR 3 Sec., 1250A. 3-PHASE, SF6 CIRCUIT BREAKER, SUITABLE FOR SINGLE POLE OPERATION (APPLICABLE FOR LINE BAY)	02 SET
05	SP	145kV, 31.5kA FOR 3 Sec., 1600A. 3-PHASE, SF6 CIRCUIT BREAKER, SUITABLE FOR SINGLE POLE OPERATION (APPLICABLE FOR BUS-COUPLER BAY)	01 SET
06	TP	245kV, 31.5kA FOR 3 Sec., 1250A. 3-PHASE, SF6 CIRCUIT BREAKER, SUITABLE FOR THREE POLE GANG OPERATION (APPLICABLE FOR TRANSFORMER BAY)	02 SET
07		145kV, 40kA FOR 1 SEC., 600A, 5 CORE 1-PHASE CURRENT TRANSFORMER	15 NOS.
08		145kV, 3 CORE, 1-PHASE CAPACITIVE VOLTAGE TRANSFORMER	12 NOS.
09		120kV, 1-PHASE, LIGHTNING ARRESTER	12 NOS.
10		POWER TRANSFORMER, 132/33KV, 8MVA	2 NOS.
11		132KV WAVE TRAP, 1250A, 0.5mH, SINGLE PHASE	4 NOS.
12		BUS POST INSULATOR INCLUDING 4 NOS. FOR WAVE TRAP MOUNTING	14 NOS.

132KV CVT WINDING DETAILS
FOR LINE BAY AND MAIN BUS
CVT RATIO: 132/√3/0.11/√3/0.11/√3/0.11/√3 kV, 4400pF

CORE	PURPOSE	CLASS	VA BURDEN
1	PROTECTION	3P	50
2	PROTECTION	3P	50
3	METERING	0.2	50

NOTES :-

1. THE EQUIPMENT INSIDE THE RED DOTTED BOX IS PART OF THE E&M PACKAGE. EVERYTHING ELSE SHOWN IS PART OF THE EXISTING INSTALLATIONS AT KORLUNG SUBSTATION.
2. ALL COMPOMENT RATINGS WILL BE REVERIFIED DURING DETAILD ENGINEERING.
3. '**' DETAILS SHALL BE FINALISED DURING DETAILED ENGINEERING.

FOR TENDER PURPOSE

CLIENT: KHORLOCHHU HYDRO POWER LIMITED, TRASHIYANGTSE, BHUTAN

CONSULTANT: Tata Consulting Engineers Ltd. & Lombardi Engineering Ltd.(JV)

PROJECT: KHORLOCHHU HYDRO POWER PROJECT(4X150 MW), TRASHIYANGTSE, BHUTAN

TITLE: 132kV SWITCHYARD SINGLE LINE DIAGRAM

DESIGNED: JC / RKR	CHECKED: LGC	RECOMMENDED:
DRAWN : ZMT	APPROVED: PLN	

DWG No: KHPP-EL-PH-SLD-4006-AU-40004

SCALE: AS SHOWN | ISSUE: P1 | DATE: 20-JUN-2025 | ORIGINAL PRINT SIZE: A1

FILE NAME: KHPP-EL-PH-SLD-4006-AU-40004

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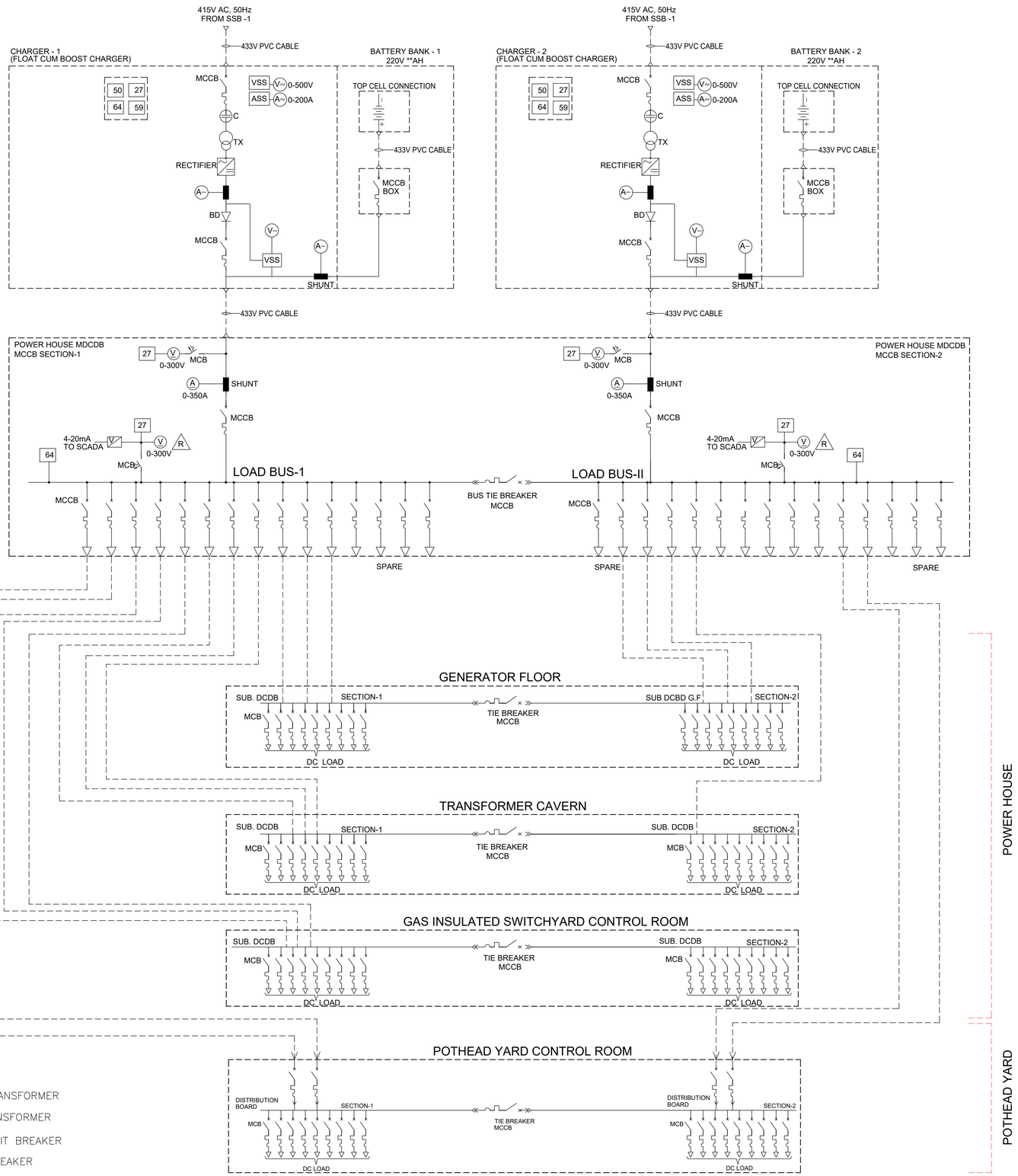
APPROV.	CIVIL	MECH.	INST.	ELEC.	STRL.	ARCH.	NATURE OF REVISION & DESCRIPTION	CHECKED	DRAWN	REV.	DATE
REVIEWED											

Khorlochhu Hydro Power Ltd.

TITLE: DC SYSTEM SINGLE LINE DIAGRAM

DWG NO KHPP-EL-PH-SLD-4006-AU-40005



SYMBOL	DESCRIPTION
	DRAW-OUT TYPE CIRCUIT BREAKER WITH THERMAL MAGNETIC O/C AND S/C RELEASE
	FIXED TYPE CIRCUIT BREAKER WITH THERMAL MAGNETIC O/C AND S/C RELEASE
	MINIATURE CIRCUIT BREAKER
	DIODE
	BATTERY
	SHUNT
	CABLE
A~	AC AMMETER
V~	AC VOLTMETER
E	ELECTRICAL INTERLOCKING
50	OVER CURRENT PROTECTION
64	EARTH FAULT PROTECTION
59	OVER VOLTAGE PROTECTION
27	UNDER VOLTAGE PROTECTION
VSS	VOLTAGE SELECTOR SWITCH
ASS	AMMETER SELECTOR SWITCH
-V	DC VOLT METER
-A	DC AMMETER
C	CONTACTOR
TX	TRANSFORMER
V TO SCADA 4-20mA	VOLTAGE TRANSDUCER
A TO SCADA 4-20mA	CURRENT TRANSDUCER
	RECTIFIER
	UNINTERRUPTIBLE POWER SUPPLY
	SERVO CONTROLLED VOLTAGE STABILIZER
	STATIC SWITCH
	CURRENT TRANSFORMER

NOTES:-

1. PROTECTION SHALL BE INTEGRAL PART OF RESPECTIVE MCCB & MCB. FOR THIS REQUIRED THERMAL MAGNETIC TYPE OVER CURRENT, SHORT CIRCUIT RELEASE SHALL BE PROVIDED INSIDE MCCB/MCB.
2. ALL BUS BARS SHALL BE ELECTRICAL GRADE COPPER BUS BARS.
3. ALL INCOMING & OUTGOING FEEDERS MCCB/MCB SHALL BE DOUBLE POLE TYPE.
4. MCCB RATINGS SPECIFIED FOR CHARGER & UPS ARE TENTATIVE, SAME SHALL BE FINALIZED AS PER MANUFACTURERS RECOMMENDATION.
5. ALL RELAYS IN CHARGER & DC BOARDS SHALL BE PART OF ELECTRONIC CARD.
6. FOR ALL INCOMER & OUTGOING MCCBs ,ALARM FOR OPEN, CLOSE & TRIP STATUS, SHALL BE CONSIDERED IN SCADA.
7. BATTERY CHARGE CURRENT RATING & BATTERY AH RATING VENDOR HAS TO CONFIRM DURING THEIR OFFER SUBMISSION.
8. '**' DETAILS SHALL BE FINALISED DURING DETAILED ENGINEERING.

ABBREVIATION

SAT	STATION AUXILIARY TRANSFORMER
SST	STATION SERVICE TRANSFORMER
MCCB	MOULDED CASE CIRCUIT BREAKER
MCB	MINIATURE CIRCUIT BREAKER
DCDB	DC DISTRIBUTION BOARD
VSS	VOLTMETER SELECTOR SWITCH
ASS	METER SELECTOR SWITCH
PVC	POLYVINYL CHLORIDE
SSB	STATION SERVICE BOARD

Khorlochhu Hydro Power Ltd.

FOR TENDER PURPOSE

CLIENT: KHORLOCHHU HYDRO POWER LIMITED
TRASHIYANGTSE, BHUTAN

CONSULTANT: Tata Consulting Engineers Ltd. & Lombardi Engineering Ltd.(JV)

PROJECT: KHORLOCHHU HYDRO POWER PROJECT(4X150 MW), TRASHIYANGTSE, BHUTAN

TITLE: DC SYSTEM SINGLE LINE DIAGRAM SHEET-1 OF 2

DESIGNED: JC / RKR	CHECKED: LGC	RECOMMENDED:
DRAWN : ZMT	APPROVED: PLN	

DWG No: KHPP-EL-PH-SLD-4006-AU-40005

SCALE: AS SHOWN | ISSUE: P1 | DATE: 20-JUN-2025 | ORIGINAL PRINT SIZE: A1

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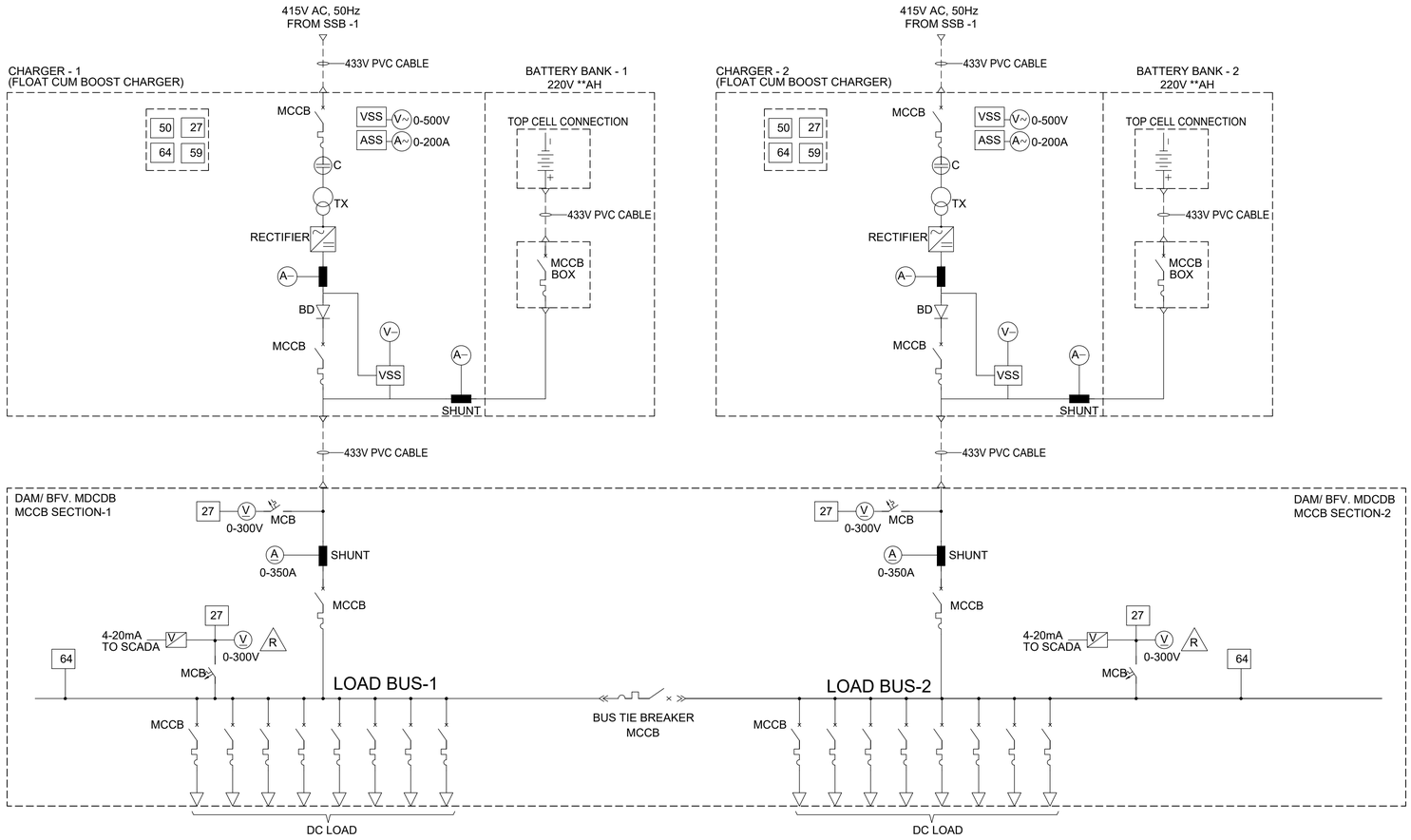
APPROV.	REVIEWED: MECH.	INST.	ELEC.	STRL.	ARCH.	NATURE OF REVISION & DESCRIPTION	CHECKED	DRAWN	REV.	DATE

TITLE: DC SYSTEM SINGLE LINE DIAGRAM

DWG NO KHPP-EL-PH-SLD-4006-AU-40005



SYMBOL	DESCRIPTION
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	FIXED TYPE CIRCUIT BREAKER WITH THERMAL MAGNETIC O/C AND S/C RELEASE
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	BATTERY
	SHUNT
	CABLE
A~	AC AMMETER
V~	AC VOLTMETER
E	ELECTRICAL INTERLOCKING
50	OVER CURRENT PROTECTION
64	EARTH FAULT PROTECTION
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VSS	VOLTAGE SELECTOR SWITCH
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C	CONTACTOR
Tx	TRANSFORMER
V TO SCADA 4-20mA	VOLTAGE TRANSDUCER
A TO SCADA 4-20mA	CURRENT TRANSDUCER
	RECTIFIER
	UNINTERRUPTIBLE POWER SUPPLY
	SERVO CONTROLLED VOLTAGE STABILIZER
	STATIC SWITCH
	CURRENT TRANSFORMER

NOTES:-

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8. '**' DETAILS SHALL BE FINALISED DURING DETAILED ENGINEERING.

FOR TENDER PURPOSE

CLIENT:
KHORLOCHHU HYDRO POWER LIMITED
TRASHIYANGTSE, BHUTAN

CONSULTANT:
Tata Consulting Engineers Ltd. &
Lombardi Engineering Ltd.(JV)

PROJECT:
KHORLOCHHU HYDRO POWER PROJECT(4X150 MW), TRASHIYANGTSE, BHUTAN

TITLE:
DC SYSTEM
SINGLE LINE DIAGRAM SHEET–2 OF 2

DESIGNED: JC / RKR	CHECKED: LGC	RECOMMENDED:
DRAWN : ZMT	APPROVED: PLN	
DWG No: KHPP–EL–PH–SLD–4006–AU–40005		
SCALE: AS SHOWN	ISSUE P1	DATE: 20–JUN–2025 ORIGINAL PRINT SIZE: A1

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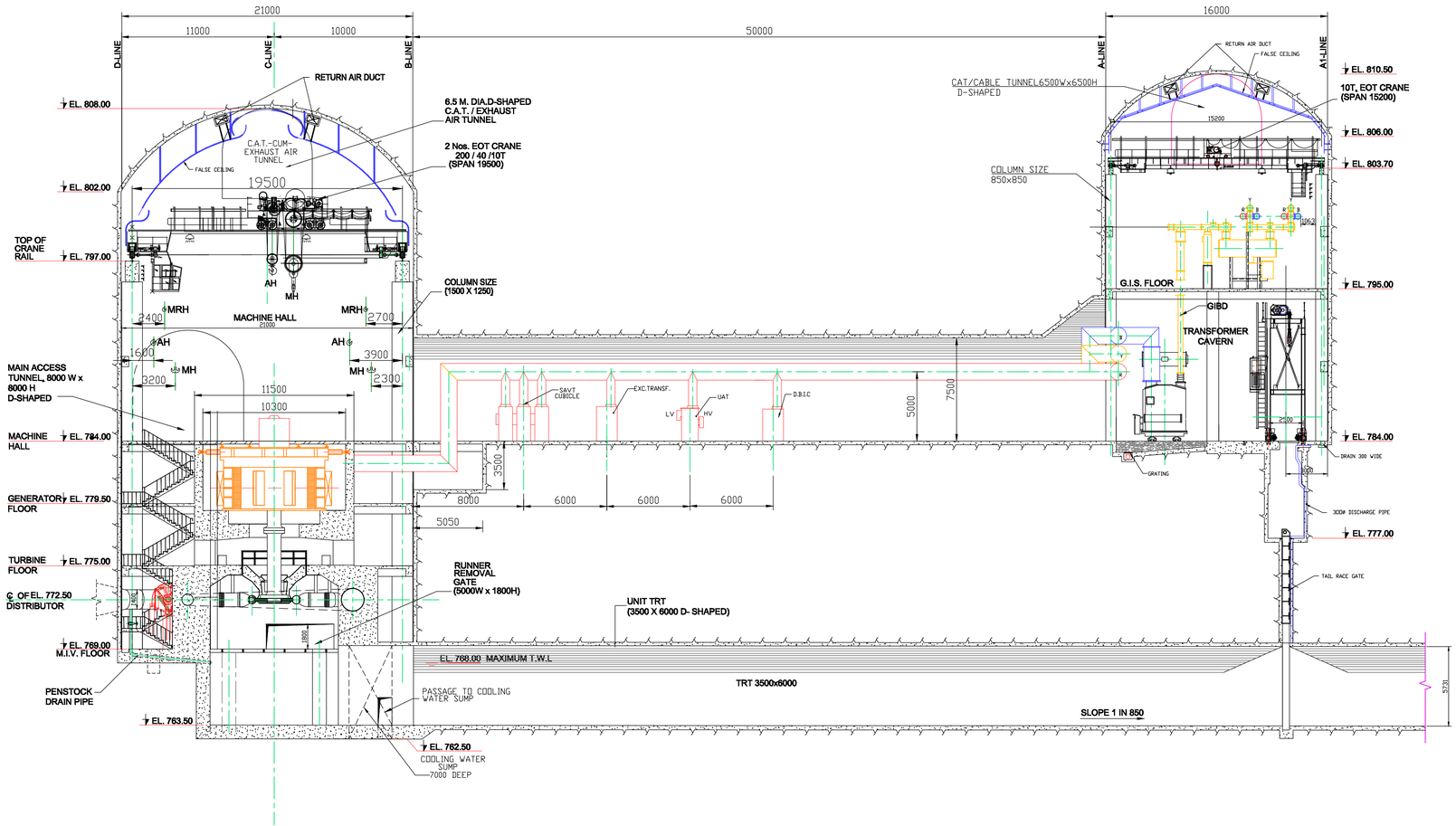
	REVIEWED									

Khorlochhu Hydro Power Ltd.

TITLE: POWER HOUSE CROSS SECTION

DWG NO KHPP-ME-6017-GA-60001



POWER HOUSE CROSS SECTION X-X

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS AND ELEVATIONS IN METERS.

FOR TENDER PURPOSE ONLY

CLIENT:
KHORLOCHHU HYDRO POWER LIMITED
TRASHIYANGTSE, BHUTAN

CONSULTANT:
Tata Consulting Engineers Ltd. &
Lombardi Engineering Ltd.(JV)

PROJECT:
KHORLOCHHU HYDRO POWER PROJECT(4X150 MW), TRASHIYANGTSE, BHUTAN

TITLE:
POWER HOUSE CROSS SECTION

DESIGNED: HY	CHECKED: AJ	RECOMMENDED:
DRAWN : ZMT	APPROVED: PLN	

DWG No: KHPP-ME-6017-GA-60001 (SHEET-1)

SCALE: AS SHOWN	ISSUE P1	DATE: 16-JUN-2025	ORIGINAL PRINT SIZE: A1

FILE NAME: KHPP-ME-6017-GA-60001

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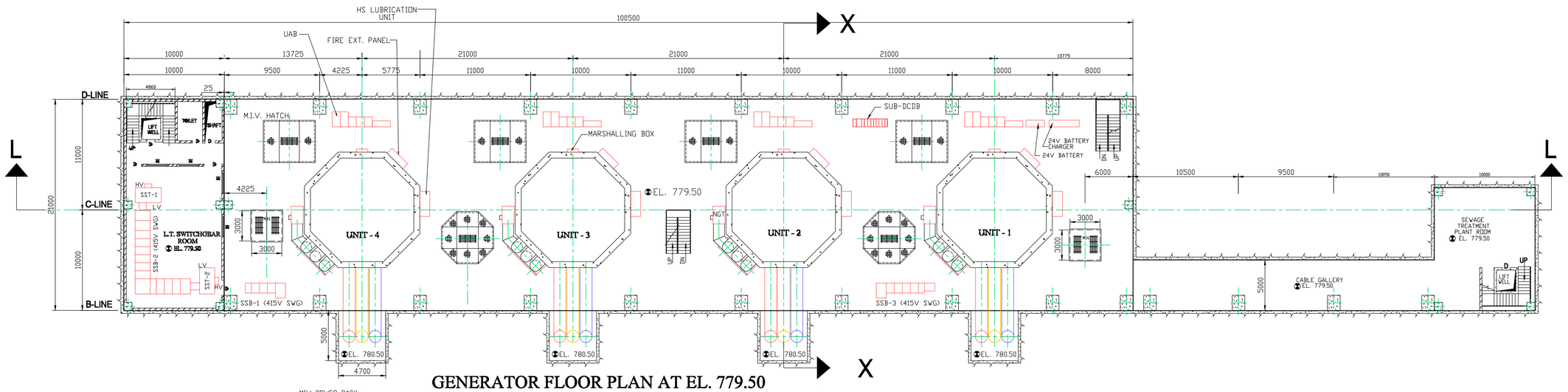
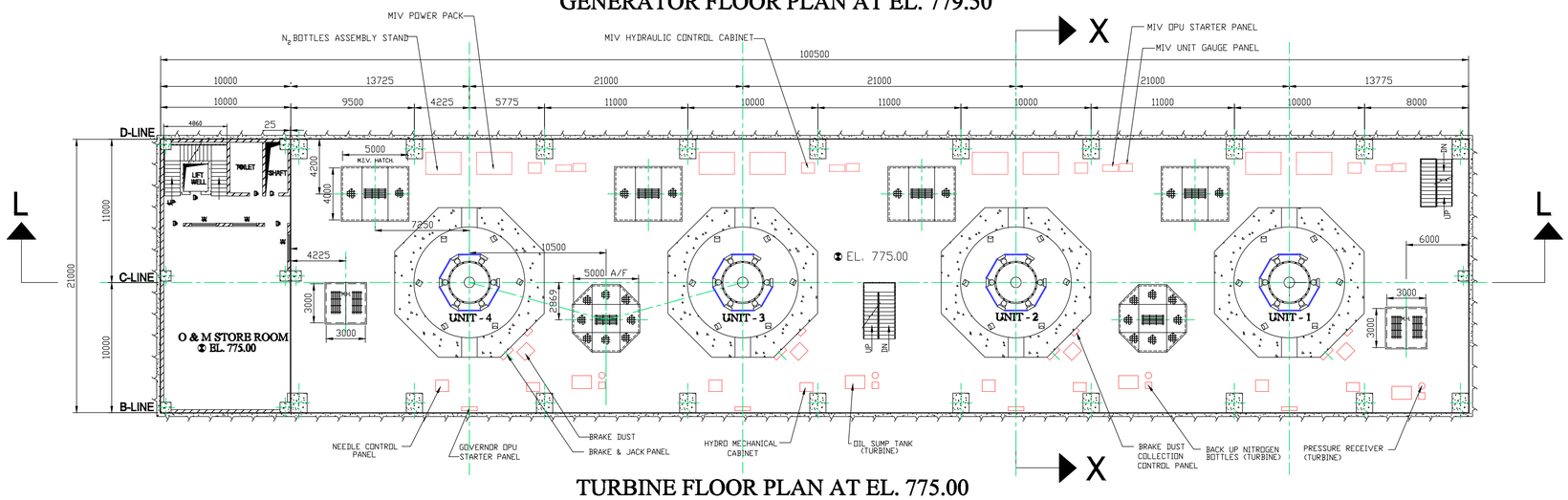
Khorlochhu Hydro Power Ltd.

TITLE: MIV FLOOR (EL.769.50m) TURBINE FLOOR (EL.775.00m) GENERATOR FLOOR (EL.779.50m)

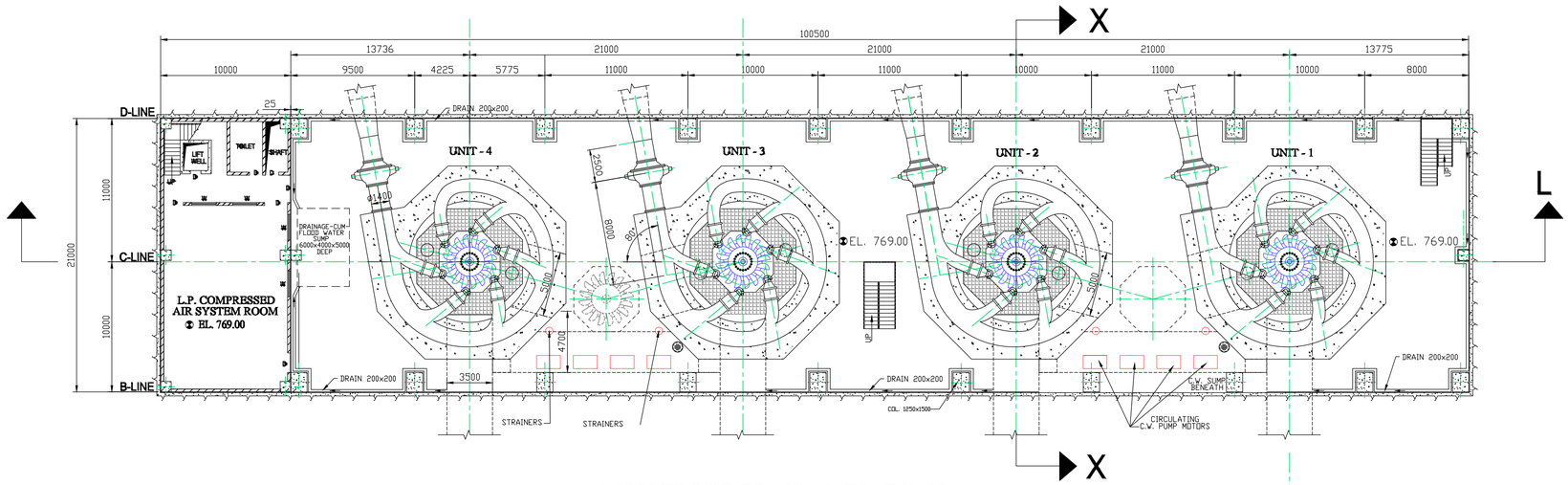
DWG NO KHPP-ME-6017-GA-60001



GENERATOR FLOOR PLAN AT EL. 779.50



TURBINE FLOOR PLAN AT EL. 775.00



M.I.V FLOOR PLAN AT EL. 769.00

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS AND ELEVATIONS IN METERS.

FOR TENDER PURPOSE ONLY

CLIENT: KHORLOCHHU HYDRO POWER LIMITED, TRASHIYANGTSE, BHUTAN

CONSULTANT: Tata Consulting Engineers Ltd. & Lombardi Engineering Ltd.(JV)

PROJECT: KHORLOCHHU HYDRO POWER PROJECT(4X150 MW), TRASHIYANGTSE, BHUTAN

TITLE: MIV FLOOR (EL.769.50m) TURBINE FLOOR (EL.775.00m) GENERATOR FLOOR (EL.779.50m)

DESIGNED: HY	CHECKED: AJ	RECOMMENDED:
DRAWN : ZMT	APPROVED: PLN	

DWG No: KHPP-ME-6017-GA-60001 (SHEET-2)

SCALE: AS SHOWN	ISSUE P1	DATE: 16-JUN-2025	ORIGINAL PRINT SIZE: A1

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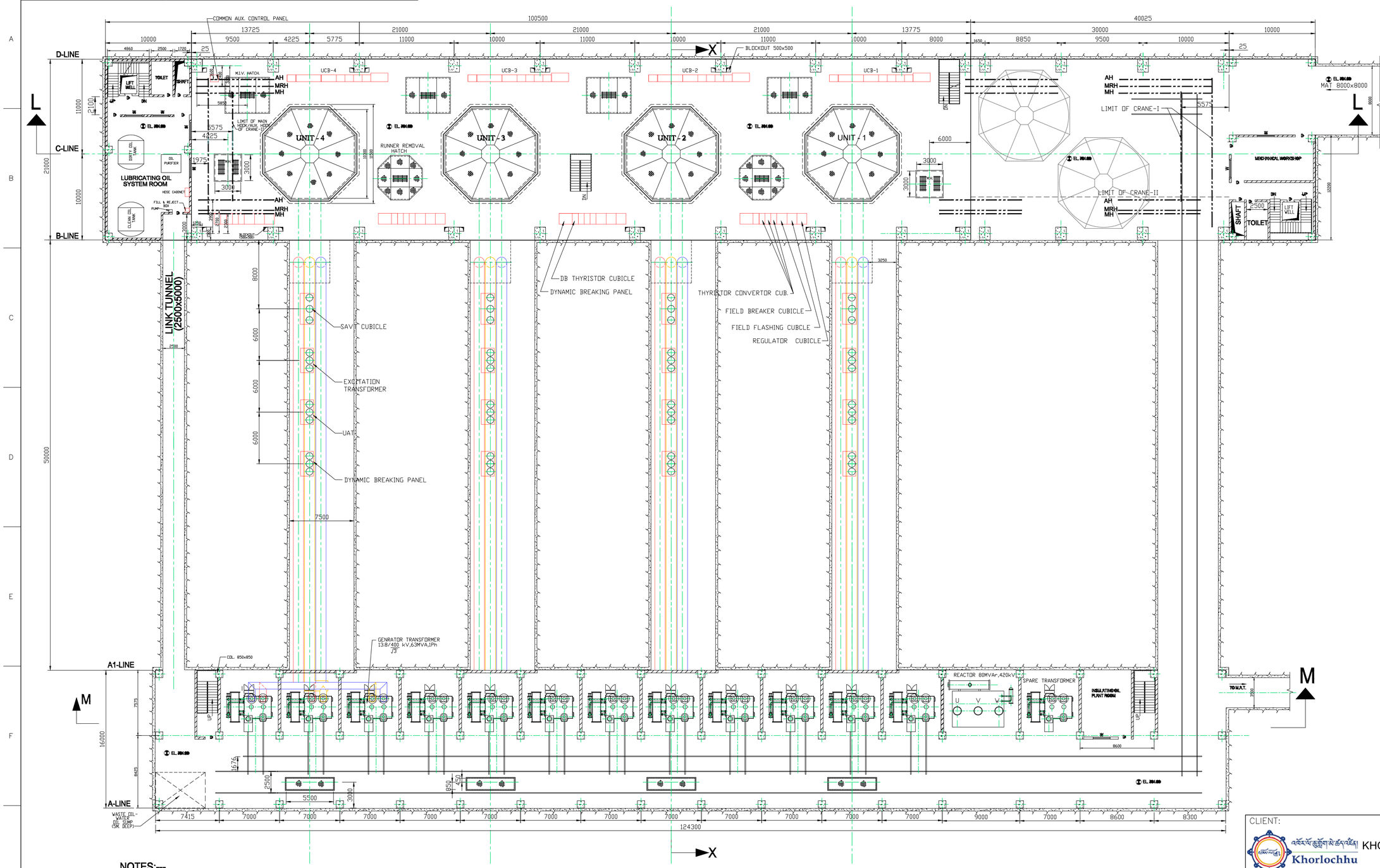
REVIEWED											

Khorlochhu Hydro Power Ltd.

TITLE: LAYOUT OF MACHINE HALL, BUSDUCT GALLERIES AND TRANFORMER HALL (EL.784.00m)

DWG NO KHPP-ME-6017-GA-60001



FOR TENDER PURPOSE ONLY

CLIENT: KHORLOCHHU HYDRO POWER LIMITED, TRASHIYANGTSE, BHUTAN

CONSULTANT: Tata Consulting Engineers Ltd. & Lombardi Engineering Ltd.(JV)

PROJECT: KHORLOCHHU HYDRO POWER PROJECT(4X150 MW), TRASHIYANGTSE, BHUTAN

TITLE: LAYOUT OF MACHINE HALL, BUSDUCT GALLERIES AND TRANFORMER HALL (EL.784.00m)

DESIGNED: HY	CHECKED: AJ	RECOMMENDED:
DRAWN : ZMT	APPROVED: PLN	
DWG No: KHPP-ME-6017-GA-60001 (SHEET-3)		
SCALE: AS SHOWN	ISSUE P1	DATE: 16-JUN-2025 ORIGINAL PRINT SIZE: A1

FILE NAME: KHPP-ME-6017-GA-60001

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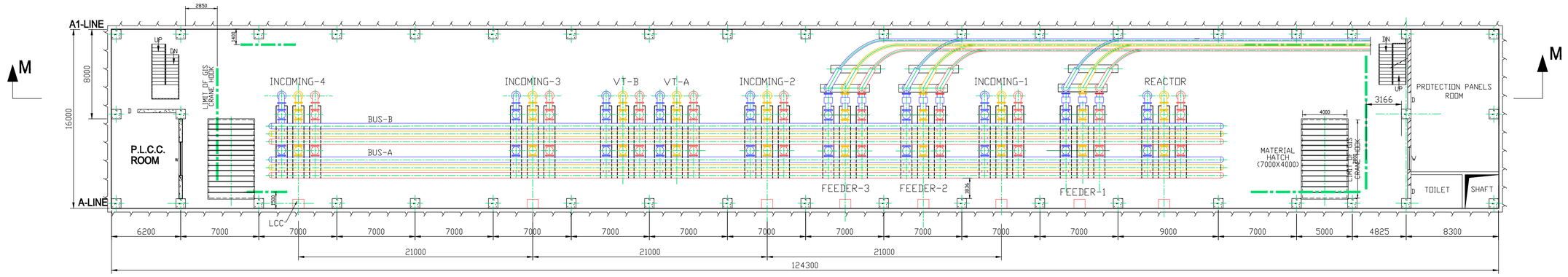
REVIEWED											

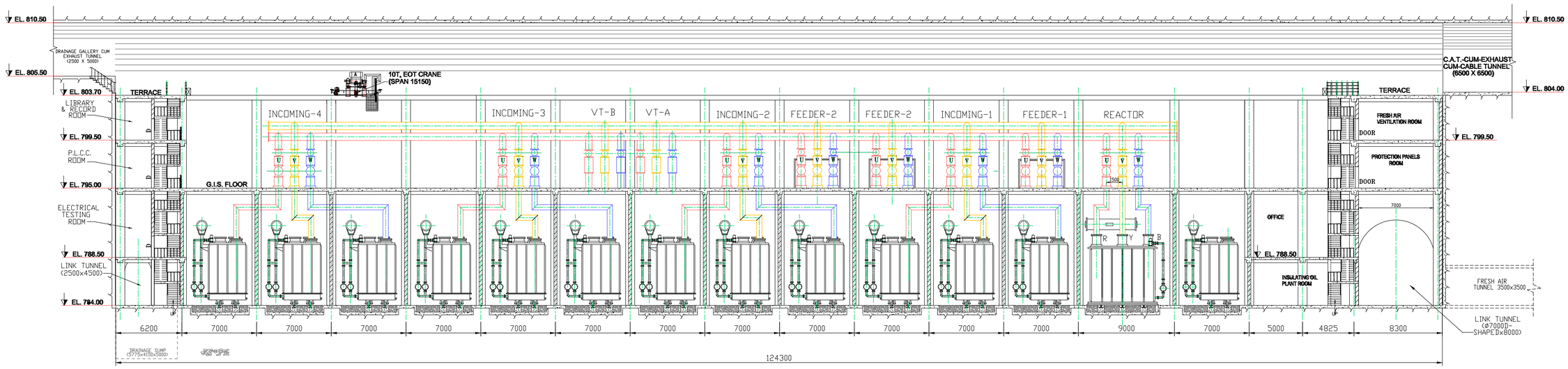
Khorlochhu Hydro Power Ltd.

TITLE: TRANSFORMER HALL LONGITUDINAL SECTION AND GIS FLOOR PLAN

DWG NO KHPP-ME-6017-GA-60001



G.I.S. FLOOR PLAN



TRANSFORMER HALL LONGITUDINAL SECTION M-M

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS AND ELEVATIONS IN METERS.

FOR TENDER PURPOSE ONLY

CLIENT:
KHORLOCHHU HYDRO POWER LIMITED
TRASHIYANGTSE, BHUTAN

CONSULTANT:
Tata Consulting Engineers Ltd. &
Lombardi Engineering Ltd.(JV)

PROJECT:
KHORLOCHHU HYDRO POWER PROJECT(4X150 MW), TRASHIYANGTSE, BHUTAN

TITLE: TRANSFORMER HALL LONGITUDINAL SECTION AND GIS FLOOR PLAN

DESIGNED: HY	CHECKED: AJ	RECOMMENDED:
DRAWN : ZMT	APPROVED: PLN	
DWG No: KHPP-ME-6017-GA-60001 (SHEET-4)		
SCALE: AS SHOWN	ISSUE P1	DATE: 16-JUN-2025

ORIGINAL PRINT SIZE: A1

FILE NAME: KHPP-ME-6017-GA-60001

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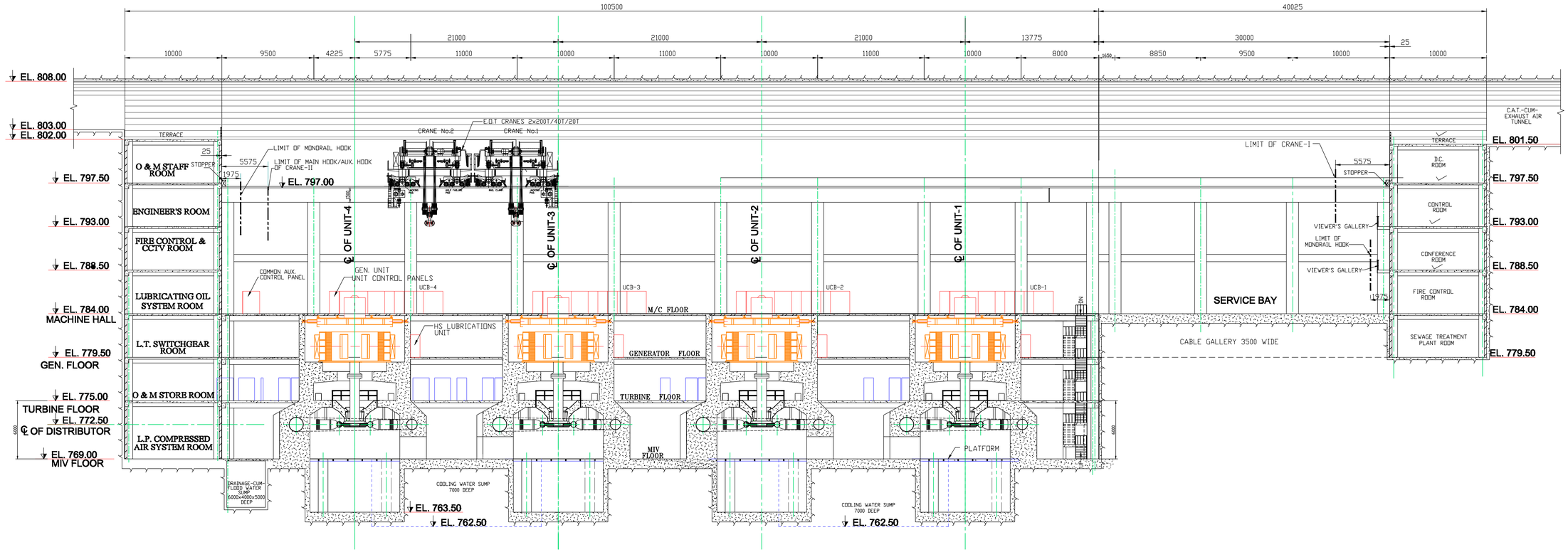
APPROV.	CIVIL	MECH.	INST.	ELEC.	STRL.	ARCH.	NATURE OF REVISION & DESCRIPTION	CHECKED	DRAWN	REV.	DATE
			REVIEWED								

TITLE: POWER HOUSE LONGITUDINAL SECTION

DWG NO KHPP-ME-6017-GA-60001



POWER HOUSE LONGITUDINAL SECTION L-L

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS AND ELEVATIONS IN METERS.

FOR TENDER PURPOSE ONLY

CLIENT:
KHORLOCHHU HYDRO POWER LIMITED
TRASHIYANGTSE, BHUTAN

CONSULTANT:
Tata Consulting Engineers Ltd. &
Lombardi Engineering Ltd.(JV)

PROJECT:
KHORLOCHHU HYDRO POWER PROJECT(4X150 MW),
TRASHIYANGTSE, BHUTAN

TITLE:
POWER HOUSE
LONGITUDINAL SECTION

DESIGNED: HY	CHECKED: AJ	RECOMMENDED:
DRAWN : ZMT	APPROVED: PLN	

DWG No: KHPP-ME-6017-GA-60001 (SHEET-5)

SCALE: AS SHOWN	ISSUE P1	DATE: 16-JUN-2025	ORIGINAL PRINT SIZE: A1

FILE NAME: KHPP-ME-6017-GA-60001

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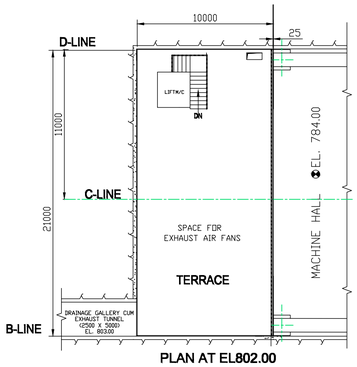
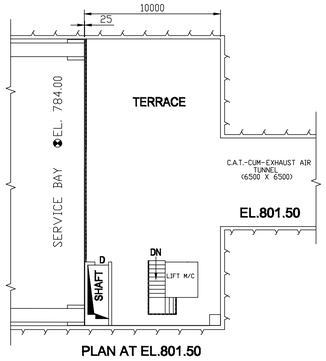
APPROV.	REVIEWED: CIVIL	MECH.	INST.	ELEC.	STRL.	ARCH.	NATURE OF REVISION & DESCRIPTION	CHECKED	DRAWN	REV.	DATE

TITLE: ANNEXE FLOOR PLANS, POWER HOUSE AND TRANSFORMER HALL

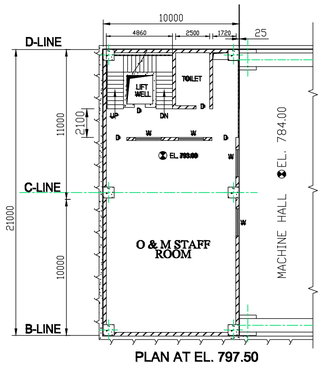
DWG NO KHPP-ME-6017-GA-60001



PLAN AT EL802.00



PLAN AT EL.801.50



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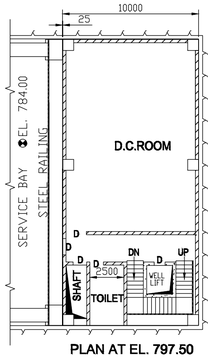

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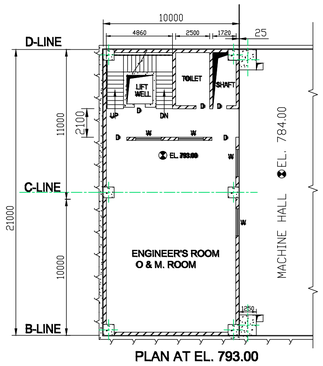

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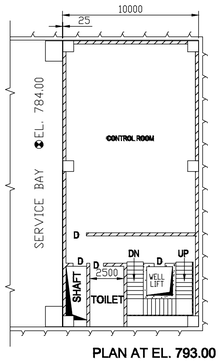

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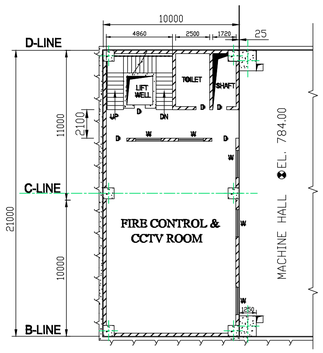
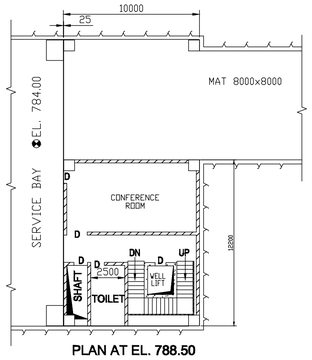


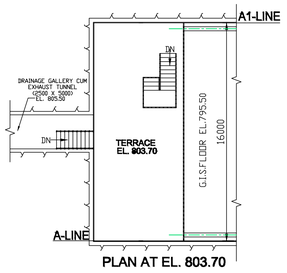
PLAN AT EL. 788.50

LAYOUT OF ANNEXE BLOCK IN MACHINE HALL UNIT-4 SIDE



PLAN AT EL. 788.50

LAYOUT OF ANNEXE BLOCK IN MACHINE HALL S/B SIDE



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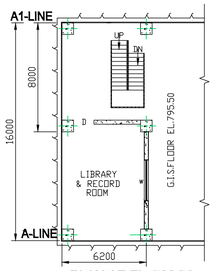
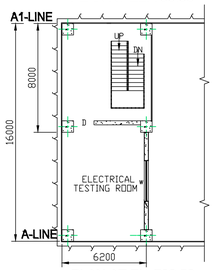
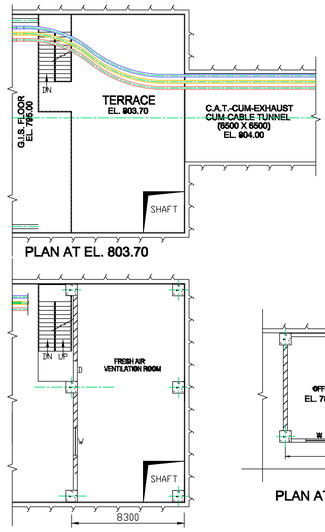


PLAN AT EL. 799.50



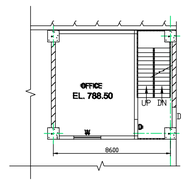
PLAN AT EL. 788.50

LAYOUT OF ANNEXE FLOORS IN TRANSFORMER HALL CAVERN UNIT-4 SIDE



PLAN AT EL. 803.70

PLAN AT EL. 799.50



PLAN AT EL. 788.50

LAYOUT OF ANNEXE FLOORS IN TRANSFORMER HALL CAVERN FAR END SIDE

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS AND ELEVATIONS IN METERS.

FOR TENDER PURPOSE ONLY

CLIENT: KHORLOCHHU HYDRO POWER LIMITED, TRASHIYANGTSE, BHUTAN

CONSULTANT: Tata Consulting Engineers Ltd. & Lombardi Engineering Ltd.(JV)

PROJECT: KHORLOCHHU HYDRO POWER PROJECT(4X150 MW), TRASHIYANGTSE, BHUTAN

TITLE: ANNEXE FLOOR PLANS, POWER HOUSE AND TRANSFORMER HALL

DESIGNED: HY	CHECKED: AJ	RECOMMENDED:
DRAWN : ZMT	APPROVED: PLN	

DWG No: KHPP-ME-6017-GA-60001 (SHEET-6)

SCALE: AS SHOWN	ISSUE P1	DATE: 16-JUN-2025	ORIGINAL PRINT SIZE: A1

FILE NAME: KHPP-ME-6017-GA-60001

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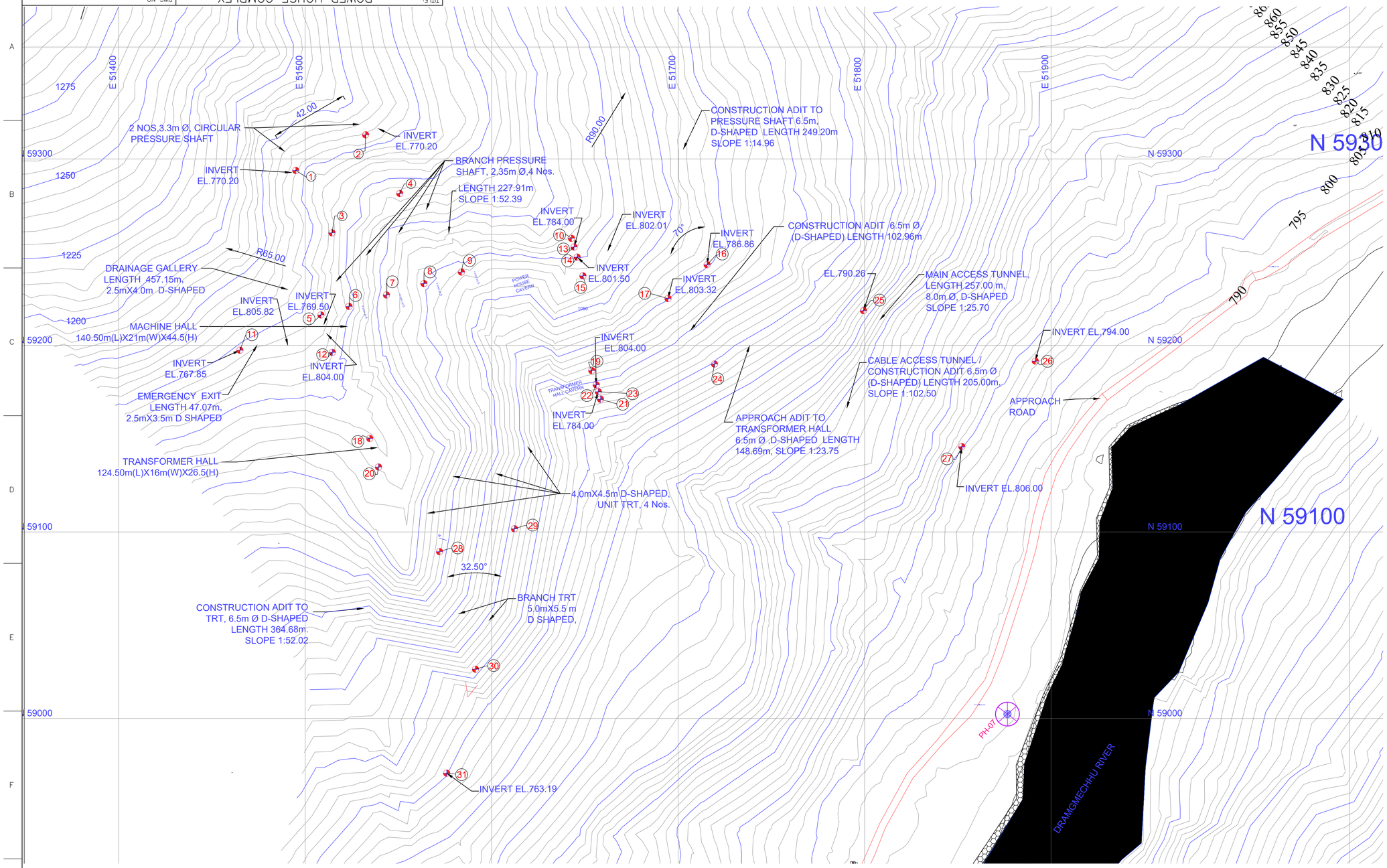
APPROV.	CIVIL	MECH.	INST.	ELEC.	STRL.	ARCH.	NATURE OF REVISION & DESCRIPTION	CHECKED	DRAWN	REV.	DATE
REVIEWED											

Khorlochhu Hydro Power Ltd.

TITLE: POWER HOUSE COMPLEX LAYOUT PLAN

DWG NO KHPP-ME-6017-CA-60001



POWER HOUSE COMPLEX LAYOUT PLAN

FOR TENDER PURPOSE ONLY

CLIENT:
KHORLOCHHU HYDRO POWER LIMITED
TRASHIYANGTSE, BHUTAN

CONSULTANT:
Tata Consulting Engineers Ltd. &
Lombardi Engineering Ltd.(JV)

PROJECT:
KHORLOCHHU HYDRO POWER PROJECT(4X150 MW), TRASHIYANGTSE, BHUTAN

TITLE:
POWER HOUSE COMPLEX LAYOUT PLAN

DESIGNED: HY	CHECKED: AJ	RECOMMENDED:
DRAWN : ZMT	APPROVED: PLN	
DWG No: KHPP-ME-6017-CA-60001 (SHEET-7)		
SCALE: AS SHOWN	ISSUE P1	DATE: 16-JUN-2025 ORIGINAL PRINT SIZE: A1

FILE NAME: KHPP-ME-6017-CA-60001

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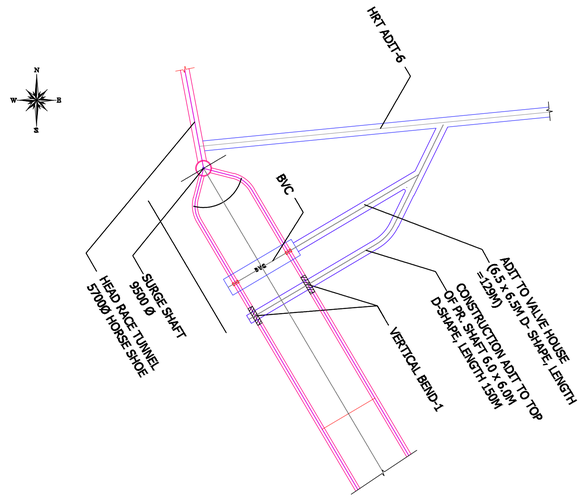
APPROV.	CIVIL	MECH.	INST.	ELEC.	STRL.	ARCH.	NATURE OF REVISION & DESCRIPTION	CHECKED	DRAWN	REV.	DATE
REVIEWED											

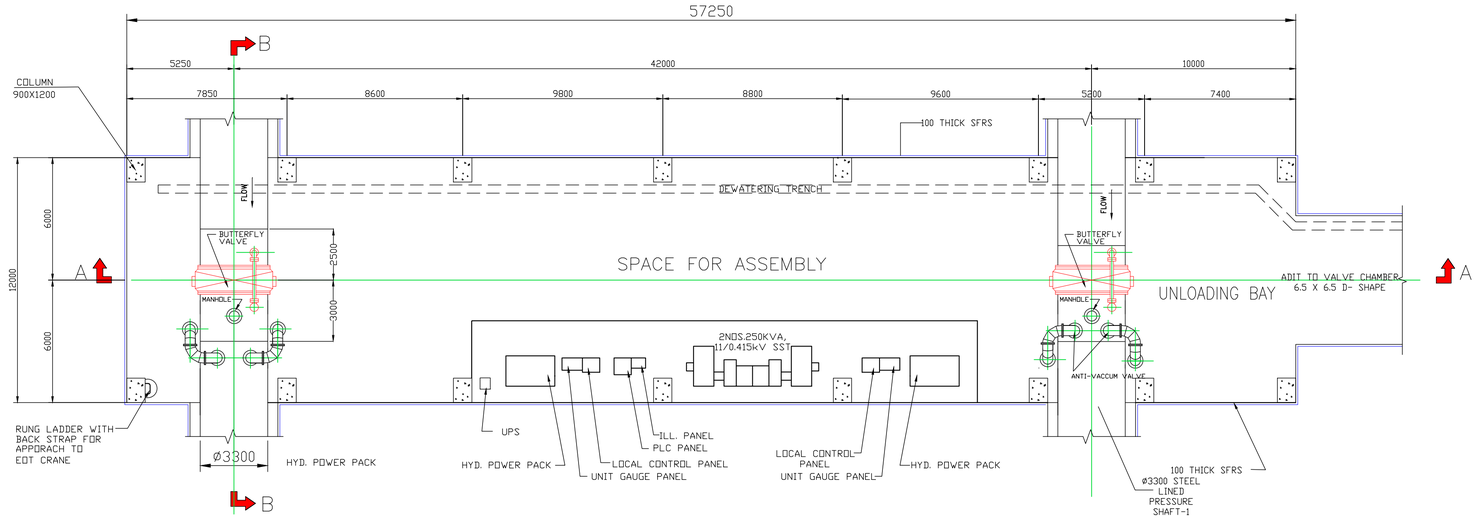
Khorlochhu Hydro Power Ltd.

TITLE: LAYOUT ARRANGEMENT OF BFV CHAMBER

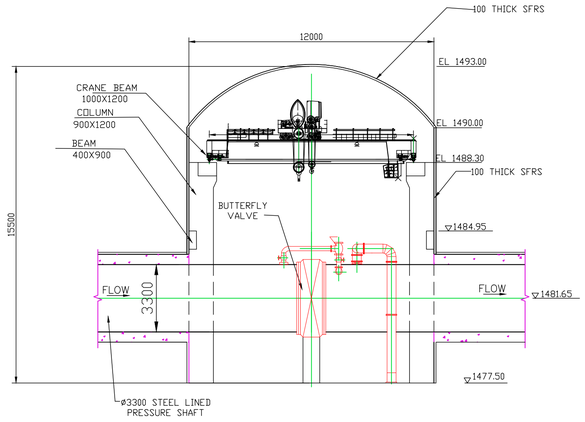
DWG NO KHPP-ME-6017-GA-60003



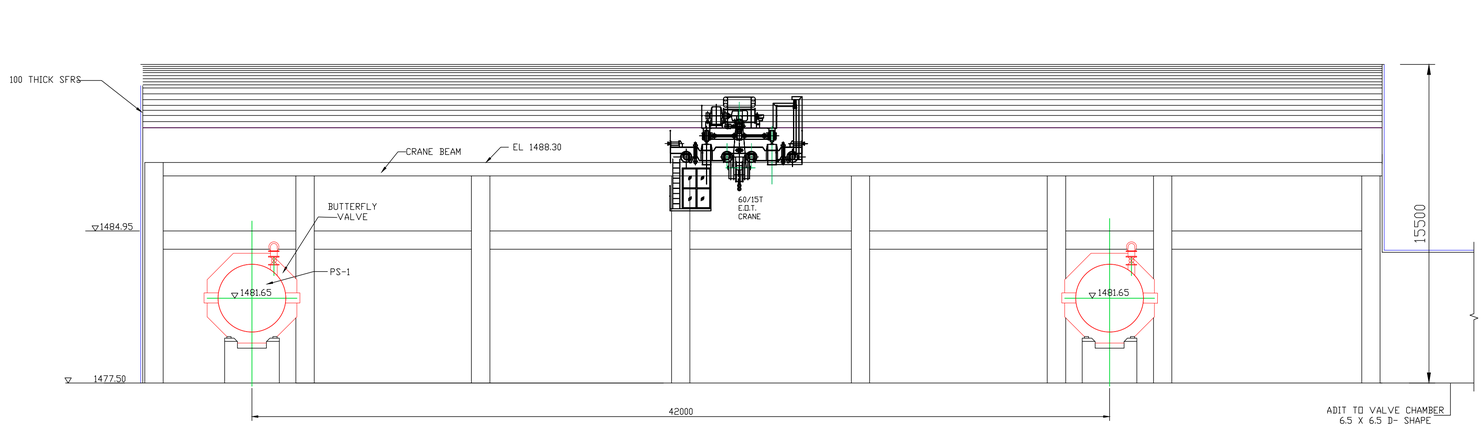
KEY PLAN OF BFV CHAMBER



PLAN



SECTION B–B



SECTION A–A

NOTES:

ALL DIMENSIONS ARE IN MILLIMETERS AND ELEVATIONS IN METERS.

FOR TENDER PURPOSE ONLY

CLIENT: KHORLOCHHU HYDRO POWER LIMITED, TRASHIYANGTSE, BHUTAN

CONSULTANT: Tata Consulting Engineers Ltd. & Lombardi Engineering Ltd.(JV)

PROJECT: KHORLOCHHU HYDRO POWER PROJECT(4X150 MW), TRASHIYANGTSE, BHUTAN

TITLE: LAYOUT ARRANGEMENT OF BFV CHAMBER

DESIGNED: HY	CHECKED: AJ	RECOMMENDED:
DRAWN : ZMT	APPROVED: PLN	

DWG No: KHPP-ME-6017-GA-60003

SCALE: AS SHOWN	ISSUE P1	DATE: 16-JUN-2025	ORIGINAL PRINT SIZE: A1

FILE NAME: KHPP-ME-6017-GA-60003

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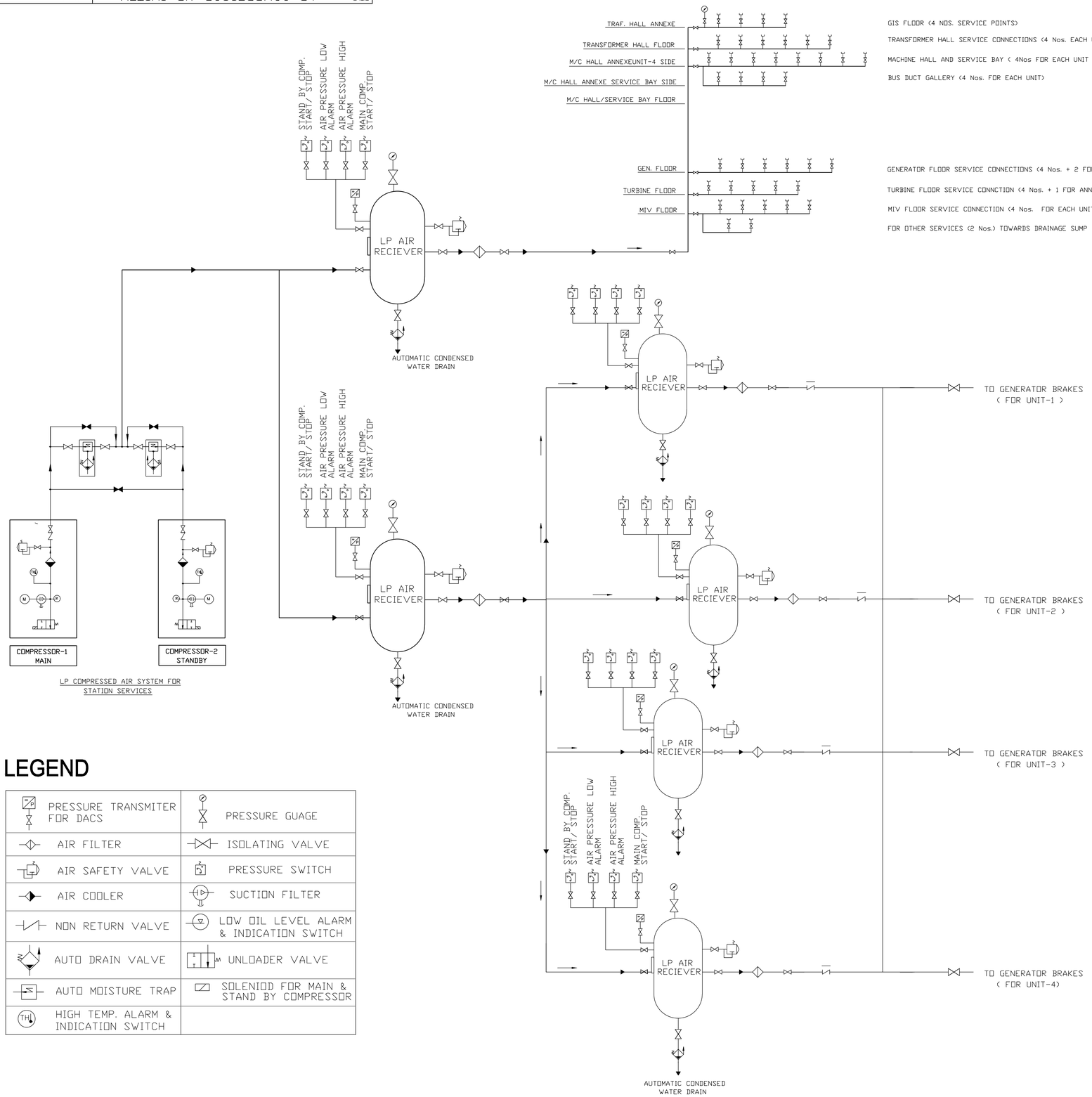
APPROV.	REVIEWED: CIVIL	MECH.	INST.	ELEC.	STRL.	ARCH.	NATURE OF REVISION & DESCRIPTION	CHECKED	DRAWN	REV.	DATE

Khorlochhu Hydro Power Ltd.

TITLE: LP COMPRESSOR AIR SYSTEM

DWG NO KHPP-ME-6017-PI-60004



LEGEND

PRESSURE TRANSMITER FOR DACS	PRESSURE GUAGE
AIR FILTER	ISOLATING VALVE
AIR SAFETY VALVE	PRESSURE SWITCH
AIR COOLER	SUCTION FILTER
NON RETURN VALVE	LOW OIL LEVEL ALARM & INDICATION SWITCH
AUTO DRAIN VALVE	UNLOADER VALVE
AUTO MOISTURE TRAP	SOLENIOD FOR MAIN & STAND BY COMPRESSOR
HIGH TEMP. ALARM & INDICATION SWITCH	

FOR TENDER PURPOSE ONLY

CLIENT: KHORLOCHHU HYDRO POWER LIMITED, TRASHIYANGTSE, BHUTAN

CONSULTANT: Tata Consulting Engineers Ltd. & Lombardi Engineering Ltd.(JV)

PROJECT: KHORLOCHHU HYDRO POWER PROJECT(4X150 MW), TRASHIYANGTSE, BHUTAN

TITLE: LP COMPRESSOR AIR SYSTEM

DESIGNED: HY	CHECKED: AJ	RECOMMENDED:
DRAWN : ZMT	APPROVED: PLN	
DWG No: KHPP-ME-6017-PI-60004		
SCALE: AS SHOWN	ISSUE P1	DATE: 16-JUN-2025
ORIGINAL PRINT SIZE: A1		

FILE NAME: KHPP-ME-6017-PI-60004

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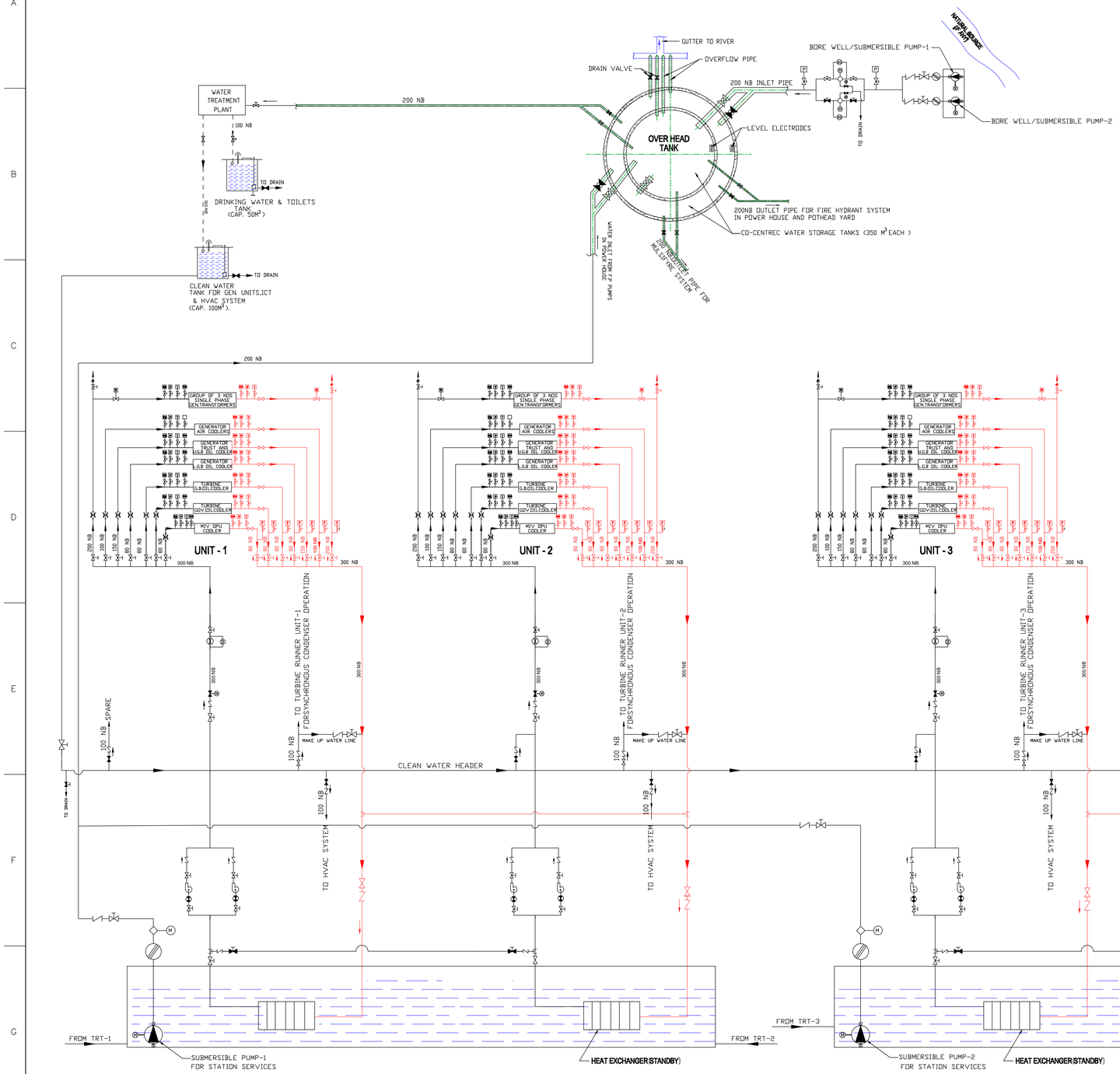
APPROV.	REVIEWED: CIVIL	MECH.	INST.	ELEC.	STRL.	ARCH.	NATURE OF REVISION & DESCRIPTION	CHECKED	DRAWN	REV.	DATE

TITLE: COOLING WATER SYSTEM SCHEMATIC DIAGRAM

DWG NO KHPP-ME-6017-PI-60005



LEGEND

	CENTRIFUGAL PUMP
	FLOAT VALVE
F	FLOW RELAY
T	TEMPERATURE GAUGE
	GATE VALVE
	NON RETURN VALVE
P	PRESSURE GAUGE
	MOTORISED VALVE
	HEAT EXCHANGER
	GATE VALVE(NORMALLY CLOSED)
	AIR VENT
	PRESSURE REDUCER
	AUTOMATIC AIR RELEASE VALVE
	BORE WELL/SUBMERSIBLE PUMP
PS	PRESSURE SWITCH
	ORIFICE
DS	DIFFERENTIAL SWITCH
M	AUTO STRAINER(MOTORISED)
	PRESSURE REGULATING VALVE
	CYCLONE SEPARATOR
	STRAINER
RTD	RESISTANT TEMPERATURE DETECTOR

FOR TENDER PURPOSE ONLY

CLIENT:
KHORLOCHHU HYDRO POWER LIMITED
TRASHIYANGTSE, BHUTAN

CONSULTANT:
Tata Consulting Engineers Ltd. & Lombardi Engineering Ltd.(JV)

PROJECT:
KHORLOCHHU HYDRO POWER PROJECT(4X150 MW), TRASHIYANGTSE, BHUTAN

TITLE:
COOLING WATER SYSTEM SCHEMATIC DIAGRAM

DESIGNED: HY	CHECKED: AJ	RECOMMENDED:
DRAWN : ZMT	APPROVED: PLN	
DWG No: KHPP-ME-6017-PI-60005		
SCALE: AS SHOWN	ISSUE P1	DATE: 16-JUN-2025
ORIGINAL PRINT SIZE: A1		

FILE NAME: KHPP-ME-6017-PI-60005

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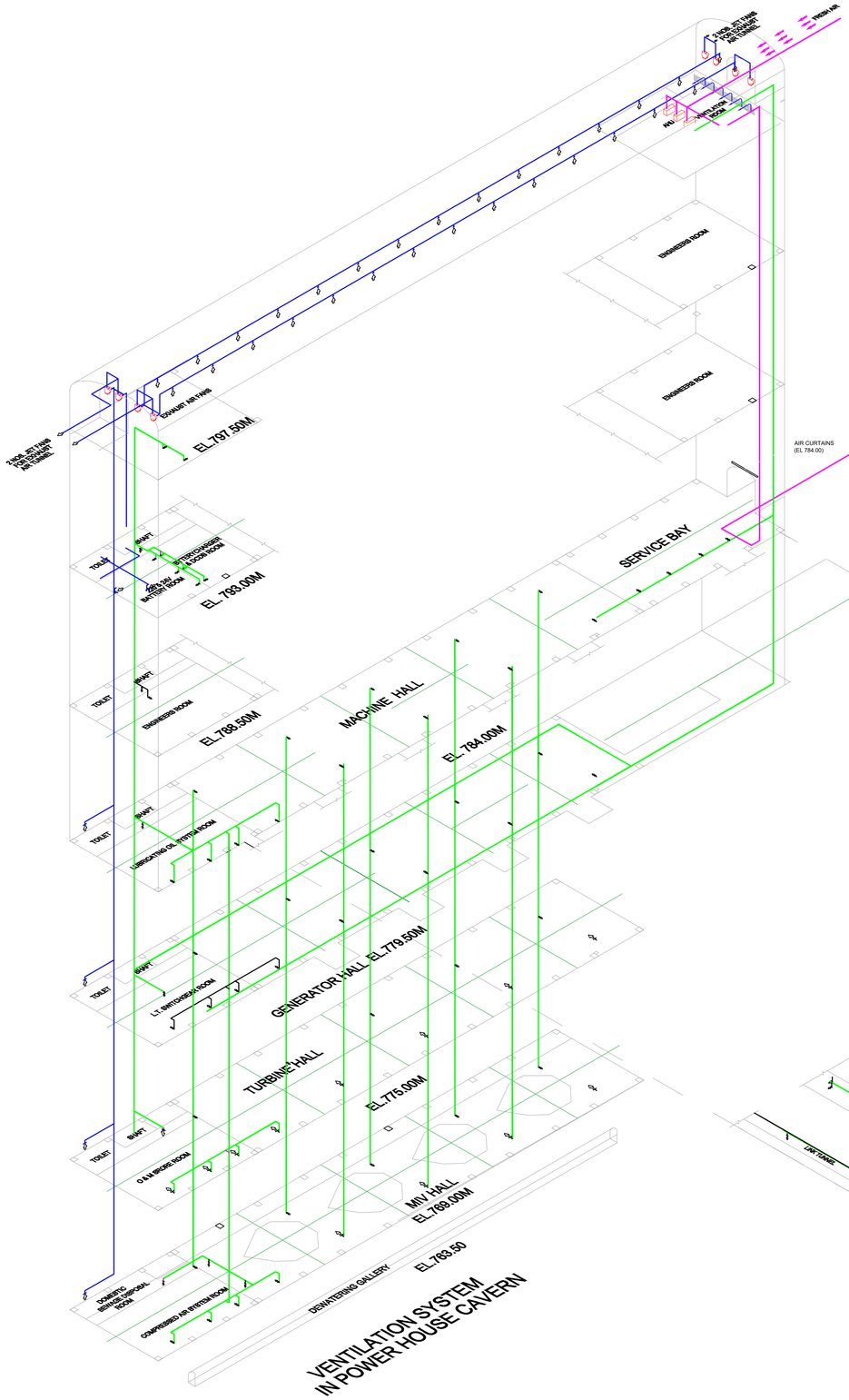
APPROV.	CIVIL	MECH.	INST.	ELEC.	STRL.	ARCH.	NATURE OF REVISION & DESCRIPTION	CHECKED	DRAWN	REV.	DATE

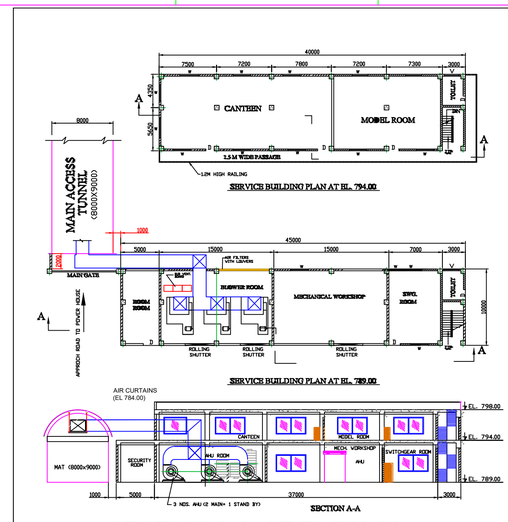
REVIEWED

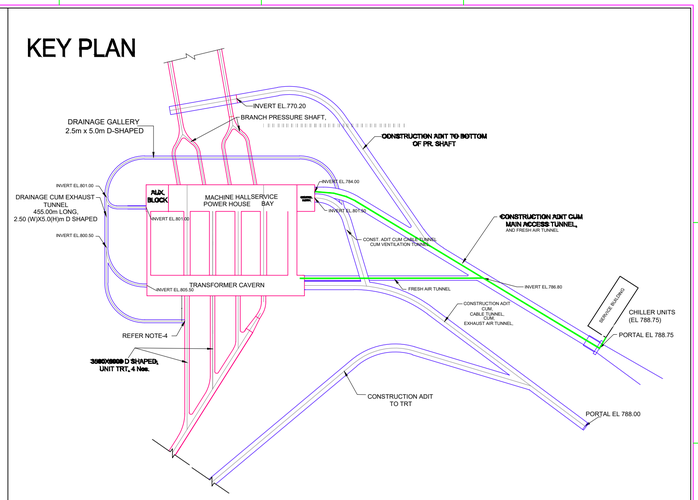
Khorlochhu Hydro Power Ltd.

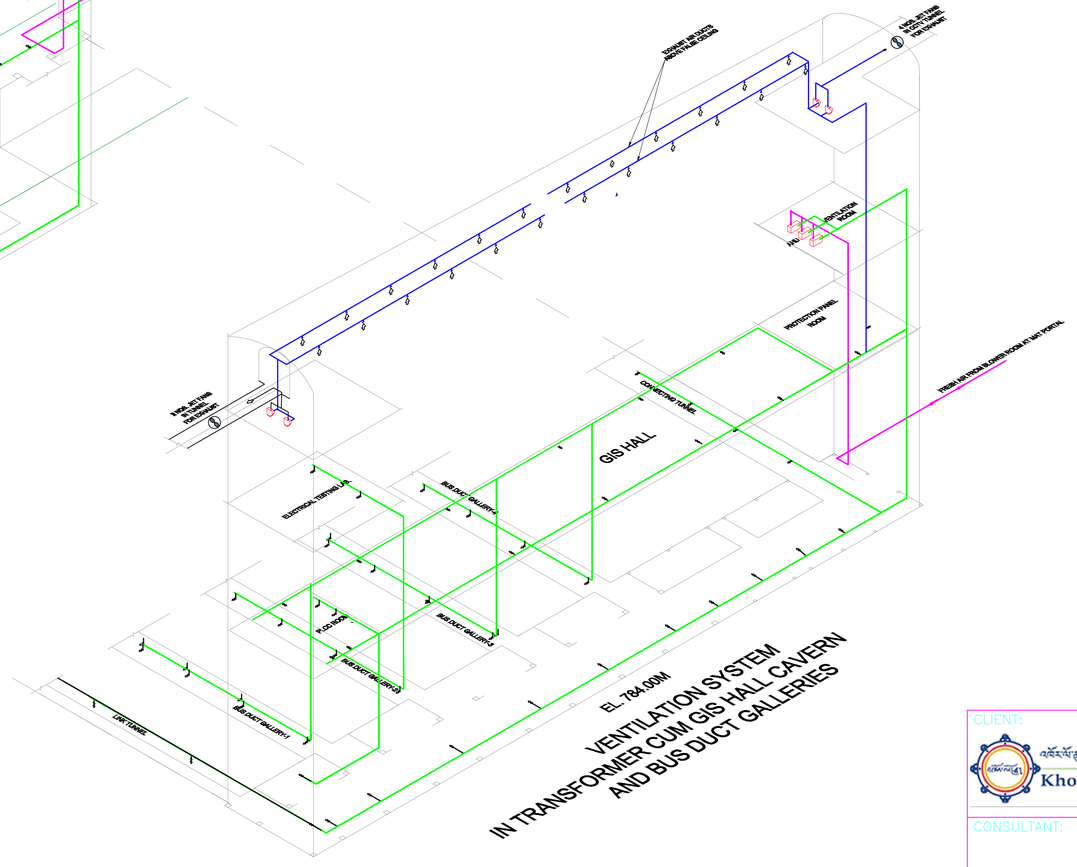
TITLE: VENTILATION SYSTEM SCHEMATIC DIAGRAM

DWG NO: KHPP-ME-6017-PI-60006









FOR TENDER PURPOSE ONLY

CLIENT: KHORLOCHHU HYDRO POWER LIMITED, TRASHIYANGTSE, BHUTAN

CONSULTANT: Tata Consulting Engineers Ltd. & Lombardi Engineering Ltd.(JV)

PROJECT: KHORLOCHHU HYDRO POWER PROJECT(4X150 MW), TRASHIYANGTSE, BHUTAN

TITLE: VENTILATION SYSTEM SCHEMATIC DIAGRAM

DESIGNED: HY	CHECKED: AJ	RECOMMENDED:
DRAWN : ZMT	APPROVED: PLN	

DWG No: KHPP-ME-6017-PI-60006

SCALE: AS SHOWN | ISSUE P1 | DATE: 16-JUN-2025 | ORIGINAL PRINT SIZE: A1

FILE NAME: KHPP-ME-6017-PI-60006

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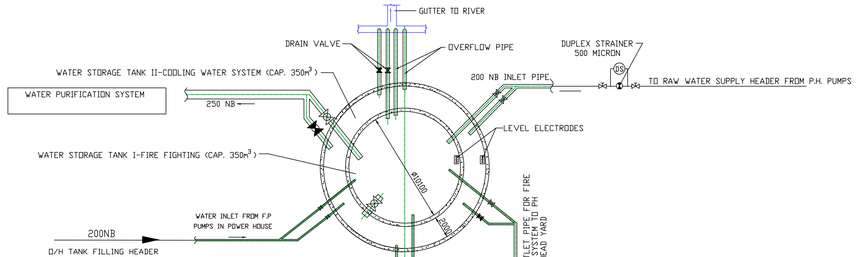
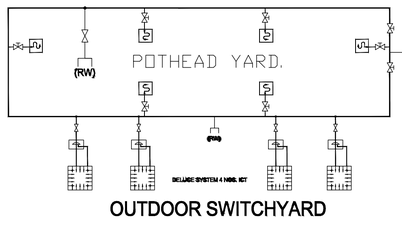
APPROV.	CIVIL	MECH.	INST.	ELEC.	STRL.	ARCH.	NATURE OF REVISION & DESCRIPTION	CHECKED	DRAWN	REV.	DATE
REVIEWED											

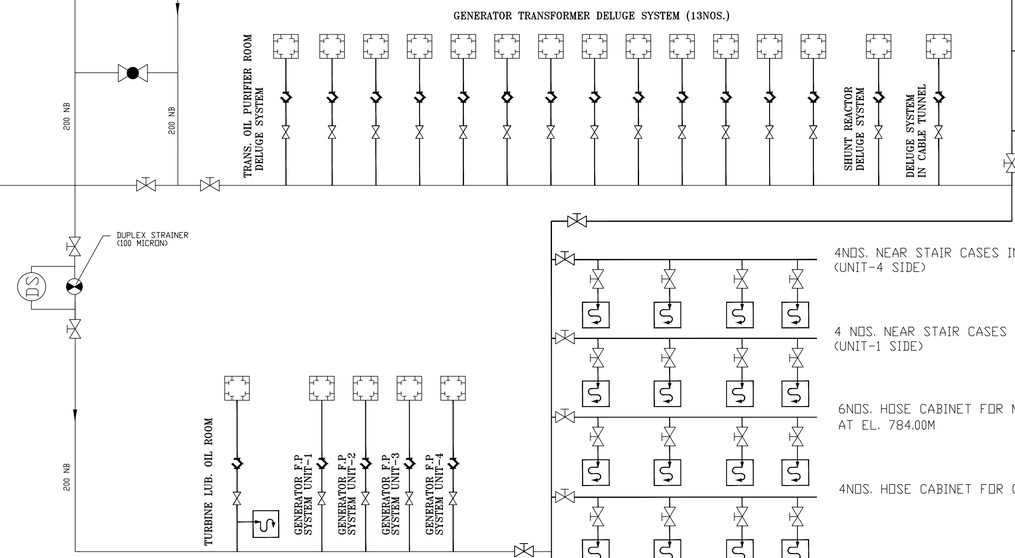
Khorlochhu Hydro Power Ltd.

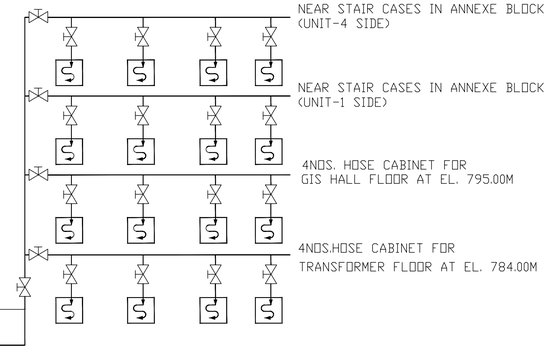
TITLE: FIRE FIGHTING PROTECTION SYSTEM SCHEMATIC DIAGRAM

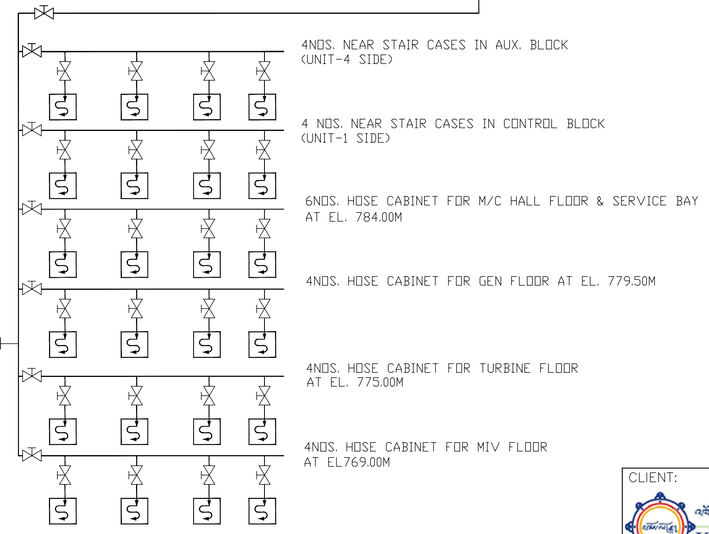
DWG NO KHPP-ME-6017-PI-60007











LEGEND

- DS — DIFFERENTIAL SWITCH
- MULSIFYRE SYSTEM RING WITH NOZZLE
- HOSE CABINET WITH HYDRANT VALVE
- DELUGE SYSTEM
- CYCLONE SEPRATOR
- GATE VALVE
- BALL VALVE(NORMALLY CLOSED)
- MOTORISED VALVE
- AIR VENT
- P — PRESSURE GAUGE
- BORE WELL/SUBMERSIBLE PUMP

FOR TENDER PURPOSE ONLY

CLIENT: KHORLOCHHU HYDRO POWER LIMITED, TRASHIYANGTSE, BHUTAN

CONSULTANT: Tata Consulting Engineers Ltd. & Lombardi Engineering Ltd.(JV)

PROJECT: KHORLOCHHU HYDRO POWER PROJECT(4X150 MW), TRASHIYANGTSE, BHUTAN

TITLE: FIRE FIGHTING PROTECTION SYSTEM SCHEMATIC DIAGRAM

DESIGNED: HY	CHECKED: AJ	RECOMMENDED:
DRAWN : ZMT	APPROVED: PLN	
DWG No: KHPP-ME-6017-PI-60007		
SCALE: AS SHOWN	ISSUE P1	DATE: 16-JUN-2025

ORIGINAL PRINT SIZE: A1

FILE NAME: KHPP-ME-6017-PI-60007

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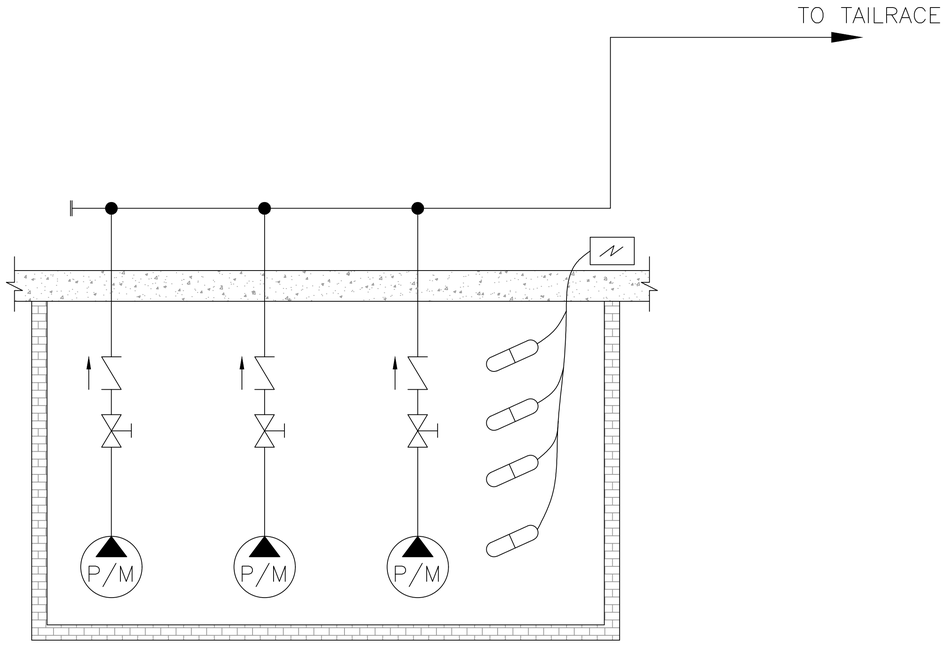
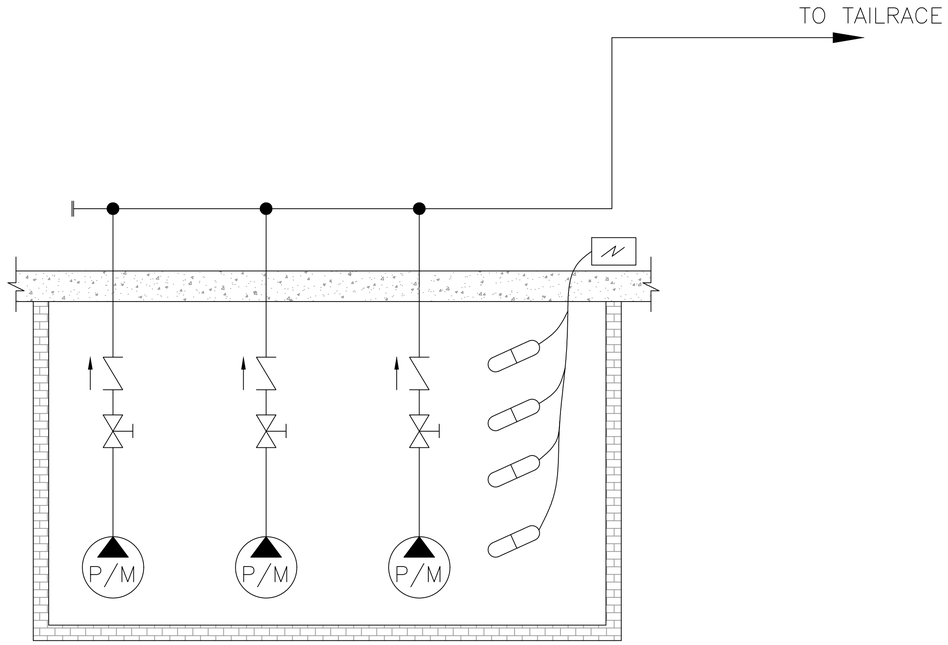
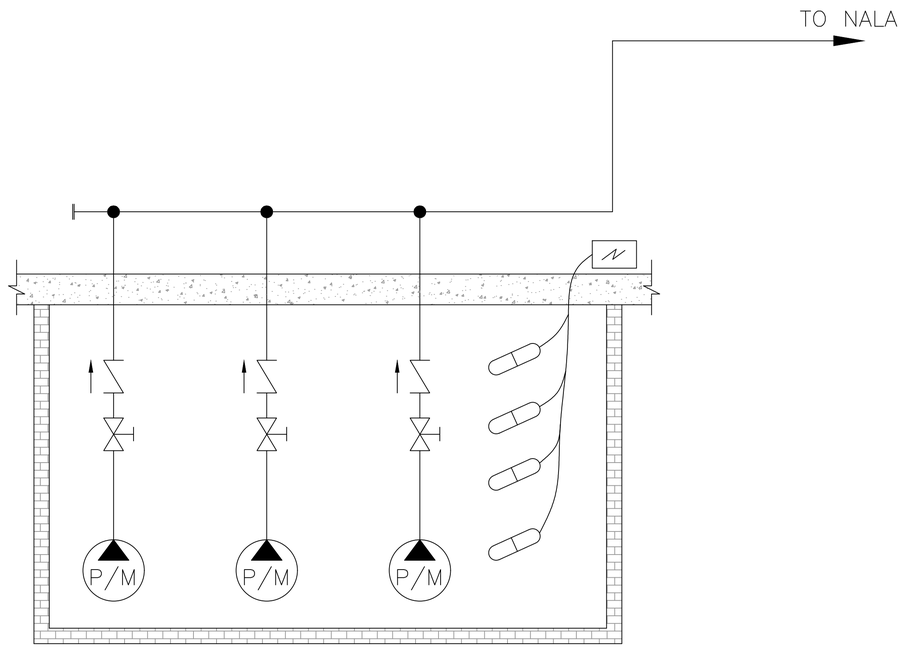
Khorlochhu Hydro Power Ltd.



SUMP #1
(AT MIV FLOOR)



SUMP #2
(AT TRANSFORMER HALL)



SUMP #3
(AT BFV CHAMBER)

LEGEND

P/M	SUBMERSIBLE PUMP
	SUBMERSIBLE PUMP
	ELECTRIC PANEL
	GATE VALVE
	NON RETURN VALVE

FOR TENDER PURPOSE ONLY

CLIENT:
KHORLOCHHU HYDRO POWER LIMITED
TRASHIYANGTSE, BHUTAN

CONSULTANT:
Tata Consulting Engineers Ltd. &
Lombardi Engineering Ltd.(JV)

PROJECT:
KHORLOCHHU HYDRO POWER PROJECT(4X150 MW),
TRASHIYANGTSE, BHUTAN

TITLE:
DRAINAGE & DEWATERING SYSTEM
SCHEMATIC DIAGRAM

DESIGNED: HY	CHECKED: AJ	RECOMMENDED:
DRAWN : ZMT	APPROVED: PLN	
DWG No: KHPP-ME-6017-PI-60008		
SCALE: AS SHOWN	ISSUE P1	DATE: 16-JUN-2025 ORIGINAL PRINT SIZE: A1

FILE NAME: KHPP-ME-6017-PI-60008

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APPROV.	CIVIL	MECH.	INST.	ELEC.	STRL.	ARCH.	REVIEWED	NATURE OF REVISION & DESCRIPTION	CHECKED	DRAWN	REV.	DATE

KHORLOCHHU HYDRO POWER LIMITED

4x150 MW KHORLOCHHU HYDROPOWER PROJECT

TRASHIYANGTSE; BHUTAN

BIDDING DOCUMENT

FOR

CONTRACT PACKAGE: KEM-1

DESIGN, MANUFACTURING, SUPPLY, INSTALLATION, TESTING AND COMMISSIONING OF ELECTRO-MECHANICAL WORKS

VOLUME - 6

TECHNICAL DATA SHEETS

International Competitive Bidding

These documents are meant for the exclusive purpose of bidding against this NIT and shall not be transferred, reproduced or otherwise used for purposes other than that for which they are specifically issued.

Tender Ref. No. KHPL/C&PD/TENDER:KEM-1/2025/11534 dt. 07.08.2025

LAYOUT OF BIDDING DOCUMENTS

CONTRACT PACKAGE: KEM-1

Design, Manufacturing, Supply, Installation, Testing and Commissioning of Electro-Mechanical Works

Volume - 1: Instructions to Bidders (ITB)

- Section - 1 Abridged Notice Inviting Tender and Notice Inviting Tender (NIT)
- Section - 2 Instructions to Bidders (ITB), Bid Data, Qualification Forms, Information for Bidders (IFB) and Work Schedule

Volume - 2: General Conditions of Contract (GCC) and Particular Conditions of Contract (PCC)

- Section - 3 FIDIC General Conditions of Contract (GCC) for Plant and Design-Build Contract (First Edition 1999)
- Section - 4 Particular Conditions of Contract (PCC)
- Section - 5 Forms and Procedures
  - Form-1: Letter of Tender
  - Form-2: Form of Contract Agreement
  - Form-3: Bank Guarantee Form for Performance Security
  - Form-4: Bank Guarantee Form for Advance Payment
  - Form-5: Form of Taking Over Certificate
  - Form-6: Bank Guarantee Form for Release of Retention Money
  - Form-7: Hindrance Register
  - Form-8: Dispute Adjudication Agreement
  - Form-9: Parent/Holding Company Agreement
  - Form-10: Proforma for Joint Deed of Undertaking

Volume-3: Price Schedules

Volume-4: Employer's Requirements

- Section - 6 General Technical Specifications (GTS)
- Section - 7 Particular Technical Specifications (PTS)
- Section - 8 Quality Assurance Plan (QAP)

Volume-5: Tender Drawings

Volume-6: Technical Data Sheets



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DATA SHEETS

1 GENERAL

i) The empty spaces provided in the attached forms of Technical Data Sheet (TDS) shall be filled by the Bidders. Data shall be given as applicable either introducing numeric values or clear Yes/No answers or by repetition of the choice as offered in the question. Questions not applicable shall be answered "N.A."

ii) The technical particulars which are to be guaranteed by the bidders shall be filled in as per the TDS format. The guaranteed particulars are those which are directly related to the performance of the equipment as sought in the technical specification.

iii) For some specific technical data, Bidders are required to submit the supporting documents in fulfilling of requirement from the past client as specified. Failure to produce such documents shall result in disqualification of the Bid.

iv) Where due to the question an extended answer is to be given, such an answer should be separately stated in the Tender, with the corresponding data line to be marked “Refer....."

v) Proposed deviations from the General or Particular Technical Specifications must be briefly indicated at the proper place as foreseen in the Technical Data Sheets. They may be compiled and described in more detail either exclusively or additionally in only one separate schedule stating both the original requirements and the Tenderer’s proposition. Deviations elsewhere stated in the Tender will not be considered and accepted.

vi) Where repeated technical data are required for a series of equipment, the relevant pages of the technical data sheets may be used and the page number amended by suffix A, B, C, etc.

vii) In principle, the Bidder shall submit all technical data and all other information called for together with his Tender. Fundamental design data, losses, efficiencies, main dimensions, weights and other important parameters have to be given highest priority.

viii) Missing technical data which are not given with the Tender have to be submitted before award of the Contract.

ix) The technical data as finally agreed upon and entered into the Contract Documents constitute the minimum achieved target. The full scope of technical data shall be resubmitted at the proper time during contract implementation, duly filled in or corrected with the technical data as per agreed final design.

x) This implies that the Contractor may propose at his discretion other data in compliance with his final choice of equipment, provided such data are not inferior compared with the contractual ones and any improvement shall be provided free of extra cost.

xi) The Bidder may propose a variety of manufacturers or sub vendors for the individual equipment, provided all such companies are listed in the Data Sheets or are tabled elsewhere. Upon award of contract, the Employer/Employer's Representative may accept any or all proposed companies, then binding for execution.

xii) The statement "or equivalent" implies that the first choice remains with the companies explicitly mentioned and the Employer/Employer's Representative reserves the right to accept or reject without justification any future new proposal.

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xiii) In case of discrepancies between data as required by Technical Specifications and those stated in the Data Sheets, the Stringent Specifications take precedence.

2 DATA SHEET-1: TECHNICAL PARTICULARS

2.1 Turbine and Accessories

2.1.1 Guaranteed Technical Particulars

Item No.	Parameter	Units	Contractor's Data	Remarks
1	**General**			
1.1	Manufacturer	-		
1.2	Place of manufacture	-		
1.3	Type/designation			
1.4	Applicable standards	-		
2	**Performance Data**			
2.1	Turbine output			
i)	Turbine rated output at rated net head of 761.5 m, within 85% nozzle opening and at rated speed	MW		
ii)	Turbine rated output at rated net head of 761.5m, within 100% nozzle opening and at rated speed	MW		
iii)	Maximum output at the following heads and at rated speed:	MW		
a)	Rated net head of 761.5m	MW		
b)	Maximum net head of 766.2m	MW		
c)	Minimum net head 752.2 m	MW		
iv)	Minimum output at the following heads and at rated speed:			
a)	Rated net head of 761.5m	MW		
b)	Maximum net head of 766.2m	MW		
c)	Minimum net head 752.2 m	MW		
2.2	Speed			
i)	Specific speed	Rpm kW-m		
ii)	Rated Speed	rpm		
iii	Critical speed for combined turbine and generator	rpm		
iv	Maximum runaway speed	rpm		
2.3	Direction of rotation (viewed from top)	-		
2.4	Minimum load at which turbine can safely operate	MW		
2.5	Factor of Safety			

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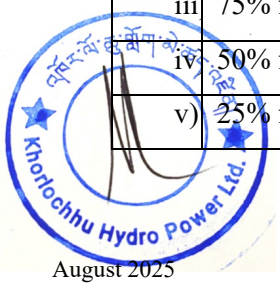
Item No.	Parameter	Units	Contractor's Data	Remarks
i)	Guaranteed minimum factor of safety under worst conditions based on minimum yield point of the material			
ii)	Name and location of the part having the factor of safety in a) above			
2.6	Weighted average efficiency (according to the particular technical specification)	%		
2.7	Momentary rise in speed on suddenly reducing the load (load throw off) to zero from the following loads at net head of 761.5m:			
i)	110% of full load	%		
ii)	Full load	%		
iii	75% of full load	%		
iv	50% of full load	%		
v)	25% of full load	%		
2.8	Time of deflector operation and needle Closure for above regulation in 2.7			
i)	110% full load to zero	s		
ii)	Full load to zero	s		
iii	75% full load to zero	s		
iv	50% full load to zero	s		
v)	25% full load to zero	s		
2.9	Momentary drop in speed on increasing load from zero to			
i)	110% of full load	%		
ii)	Full load	%		
iii	75% of full load	%		
iv	50% of full load	%		
v)	25% of full load	%		
2.10	Time of needle opening for above regulation in 2.9			
i)	110% full load	s		
ii)	Full load	s		
iii	75% full load	s		
iv	50% full load	s		
v)	25% full load	s		



Item No.	Parameter	Units	Contractor's Data	Remarks
2.11	Maximum runaway speed at following net head and at generator no load (except friction loss)			
i)	At maximum net head	rpm		
ii)	At design net head	rpm		
iii	At minimum net head	rpm		
2.12	Maximum water hammer over-pressure when all 4 units at 110% full load and simultaneously rejecting load	%		
2.13	Flywheel effect (GD^2) available for regulation as 2.12 above			
i)	Contribution from turbine rotating parts	tm^2		
ii)	Contribution from generator rotating parts	tm^2		
2.14	Cavitation guarantee based on 24 months, or 8000 hrs. of operation as specified in PTS	kg		
2.15	Minimum runner splitter thickness of the runner bucket	mm		
2.16	Maximum noise level at any place at a distance of 1 m at rated operation in turbine pit	dB(A)		
2.17	Maximum guide bearing temperature under permissible operating range of turbine			
i)	Metal temperature	ºC		
ii)	Oil temperature	ºC		
2.18	Losses in the bearing at rated operating conditions	kW		
2.19	Capability of guide bearing to withstand			
i)	At runaway speed with cooling water	Min		
ii)	At rated speed without cooling water	Min		
iii	At runaway speed without cooling water	Min		
iv	At stresses resulting from operation of unit with three adjacent nozzles in closed position	Yes/No		
2.20	Turbine water discharge quantities			
i)	At rated output at rated head	m^3/s		
ii)	At maximum output at rated net head	m^3/s		
iii	At maximum runaway condition at maximum net head	m^3/s		
iv	At no load at rated net head	m^3/s		

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Item No.	Parameter	Units	Contractor's Data	Remarks
2.21	Permissible limit of water and oil leakages			
i)	Permissible limit of water leakage through nozzle servomotor (water leakage line) at maximum overload at rated net head	L/s		
ii)	Permissible limit of oil leakage through nozzle servomotor (oil leakage line) at maximum overload at rated net head	L/s		
2.22	Maximum hydraulic axial thrust under 2 jet 4 jet & 6 jet operation	kN		
2.23	Maximum total load on thrust bearing generated from turbine	kN		
2.24	Axial thrust at 110 % rated load rejection	kN		
3.	**Material Standard/Class/Grade/Type**			
3.1	Spiral distributor			
3.2	Runner			
3.3	Nozzle tip			
3.4	Needles			
3.5	Jet deflector			
3.6	Servomotor			
3.7	Shaft			
3.8	Linkages			
3.9	Pit liner			
3.10	Bearing metal for guide bearing pads			
3.11	Type of turbine guide bearing			
3.12	Coolers			
3.13	Tube			
3.14	Tube plates			
3.15	Any other item not given above			
4.	Oil leakages from vapor seals/oil retaining sleeves/shaft seal/ labyrinth seal.	m^3/sec		
5.	Interval of major overhauling of Nozzle Injector Assembly (Major maintenance like dismantling of injector assembly and replacement of seals)	Years		
6.	Turbine operation in Condenser Mode	Yes/No		

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2.1.2 Informative Data

Item No.	Parameter	Units	Contractor's Data	Remarks
1	**Turbine runner**			
1.1	Material composition and conforming standard			
1.2	Runner Disc diameter	mm		
1.3	Pitch Circle diameter	mm		
1.4	Peripheral velocity	m/s		
1.5	Number of buckets	Nos.		
1.6	Width of Bucket	mm		
1.7	Total height	mm		
1.8	Depth of runner above C/L of Nozzles	mm		
1.9	Depth of runner below C/L of Nozzles	mm		
1.10	Weight	kg		
1.11	Transport Dimension (LxBxH)	mm		
2	**Turbine shaft**			
2.1	Material composition and conforming standard			
2.2	Shaft diameter	mm		
2.3	Internal bore dia.	mm		
2.4	Length	mm		
2.5	Critical speed for combined turbine and generator shaft	rpm		
2.6	Type of coupling with generator shaft	Type		
2.7	Flange diameter	mm		
2.8	No. and diameter of flange bolts	No. /mm		
2.9	Type of bolts	-		
2.10	General Surface finish (outside)	Micrometer		
2.11	Surface finish at bands	Micrometer		
2.12	Weight	Tonnes		
3	**Distributor**			
3.1	Type			
3.2	Material composition and conforming standard			
3.3	Internal diameter of inlet	mm		
3.4	Number of sections to be assembled at site	Nos.		

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Item No.	Parameter	Units	Contractor's Data	Remarks
3.5	Material thickness	mm		
3.6	Quadrant dimensions of the	mm		
3.7	Maximum design working pressure	kg/cm^2		
3.8	Type of coupling/jointing between section of distributor			
3.9	Test pressure	kg/cm^2		
3.10	Velocity of water at rated condition	m/s		
3.11	Size of man door provided			
3.12	Corrosion and abrasion allowance for	mm		
3.13	Total weight of distributer	Tonnes		
3.14	Weight of heaviest section	Tonnes		
3.15	Method of embedding distributor in concrete			
4	**Nozzle**			
4.1	Inlet and outlet diameter	mm		
4.2	Material of spear tip and conforming standard			
4.3	Material of nozzle tip and conforming standard			
4.4	Number of jets	nos.		
4.5	Range of movement of needle from fully closed to fully opened	mm		
5	**Brake jet nozzle**			
5.1	Material of brake jet nozzle			
5.2	Number	nos.		
5.3	Diameter	mm		
5.4	Brake jet will be			
i)	Applied at speed	%		
ii)	Removed at speed	%		
6	**Turbine Housing**			
6.1	Top Cover			
i)	Material and Construction			
ii)	Dimension of top cover	mm x mm		
iii)	Thickness	mm		
iv)	Nos. of sections	nos.		
v)	Total weight	kg		

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Item No.	Parameter	Units	Contractor's Data	Remarks
vi)	Means of Handling top cover in the pit			
vii)	Elevation of highest and lowest point			
6.2	Turbine pit liner			
i)	Inside diameter	mm		
ii)	Material construction and conforming			
iii)	Material thickness			
iv)	Elevation of highest and lowest point			
7	**Turbine guide bearing**			
7.1	Type			
7.2	Number of pads (in case of Pad type)	Nos.		
7.3	Bearing Pressure	kg/cm^2		
7.4	Running clearance	mm		
7.5	Material of Bearing pads and conforming standard			
7.6	Type, number and location of;			
i)	Embedded temperature detectors			
ii)	Dial type thermometers			
iii)	Thermostats			
iv)	Other devices			
7.7	Diameter	mm		
7.8	Height	mm		
7.9	Distance from reference level to guide	mm		
7.10	No. of coolers	Nos.		
7.11	Maximum safe working pressure	kg/cm^2		
7.12	Cooling water requirement			
i)	Quantity	lpm		
ii)	Pressure range	kg/cm^2		
7.13	Cooling Coils			
i)	Numbers	Nos.		
ii)	Maximum safe working pressure	Kg/cm^2		
iii)	bursting pressure	Kg/cm^2		

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Item No.	Parameter	Units	Contractor's Data	Remarks
iv)	Pressure drop of water through the cooling coil	Kg/cm^2		
v)	Material of construction and conforming standard			
7.14	Normal working temperature of bearing	^0C		
7.15	Maximum permissible temperature of bearing	^0C		
7.16	Volume of oil in bearing	L		
7.17	Oil specification grade and make			
7.18	Capacity of bearing oil reservoir	L		
7.19	Temperature rise by RTDs of the bearing while delivering rated output with cooling water supply at 25^0C			
i)	Pads	^0C		
ii)	Oil	^0C		
7.20	Operation capability of guide bearing (in minutes) for following conditions;			
i)	At rated speed without cooling	Min.		
ii)	At runaway speed with cooling	Min.		
iii)	At runaway speed without cooling	Min.		
7.21	Complete detail of alternative bearings, if required			
7.22	Thickness of babbit lining	mm		
7.23	Provision of Manual operated pump	Yes/No		
8	**Servomotor (Deflectors)**			
8.1	Types of servomotor			
8.2	Nos. of servomotor	nos.		
8.3	Full stroke	mm		
8.4	Bore of cylinders	mm		
8.5	Active volume	cm^3		
8.6	Max. operating pressure	bars		
8.9	Min. operating pressure	bars		
8.10	Material of construction of deflector, cylinder and piston, and conforming standard			
8.11	Max. operating energy per servomotor	kNm		

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Item No.	Parameter	Units	Contractor's Data	Remarks
8.12	Min. Operating energy per servomotor	kNm		
8.13	Arrangement details of Lock at Servomotor			
9	**Servomotor (nozzle)**			
9.1	Type			
9.2	Nos. of servomotor	Nos.		
	Material of the cylinder and piston			
9.3	Full stroke	mm		
9.4	Bore of cylinders	mm		
9.5	Active volume	cm^3		
9.6	Max. operating pressure	kg/cm^2		
9.7	Min. operating pressure	kg/cm^2		
9.8	Provision of emergency closing			
9.9	Max. operating energy per servomotor	kNm		
9.10	Min. operating energy per servomotor	kNm		
9.11	Range of adjustable opening and closing time of needle stroke			
10	**Main shaft seal/ Labyrinth seal**			
11	**Time taken**			
11.1	To attain rated speed from start command	sec		
11.2	To load the unit from zero to rated output	sec		
11.3	To reach runaway speed from normal speed in case of failure of governing system	sec		
11.4	To reach zero speed from stop command	sec		
12	**Load on thrust bearing**			
12.1	Due to turbine rotating parts	Tons		
12.2	Due to max. hydraulic thrust	Tons		
i)	Under 3 jet operation	Tons		
ii)	Under 4 jet operation	Tons		
iii)	Under 5 jet operation	Tons		
iv)	Under 6 jet operation	Tons		
12.3	Max. unbalanced hyd. Thrust during worst operation condition (specify condition also)	Tons		

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Item No.	Parameter	Units	Contractor's Data	Remarks
13	**Transient behavior**			
13.1	Nozzle opening time	s		
13.2	Nozzle closing time	s		
13.3	Maximum Pressure rise	%		
13.4	Maximum Speed rise	%		
14	**Characteristic Data**			
14.1	Turbine efficiency at rated net head of 761.5 m and rated speed			
i)	At 110 % continuous rated output	%		
ii)	At 100 % continuous rated output	%		
iii)	At 75 % continuous rated output	%		
iv)	At 50 % continuous rated output	%		
14.2	Turbine efficiency at maximum net head of 766.2 m and rated speed			
i)	At 110 % continuous rated output	%		
ii)	At 100 % continuous rated output	%		
iii)	At 75 % continuous rated output	%		
iv)	At 50 % continuous rated output	%		
14.3	Turbine efficiency at minimum net head of 752.2 m and rated speed			
i)	At 110 % continuous rated output	%		
ii)	At 100 % continuous rated output	%		
iii)	At 75 % continuous rated output	%		
iv)	At 50 % continuous rated output	%		
14.4	Best efficiency points with reference to unit speed/unit power/unit discharge	%		
14.5	Maximum runaway speed at following net head			
i)	At maximum net head of 766.2 m	rpm		
ii)	at rated net head of 761.5 m	rpm		
iii)	at minimum net head of 752.2 m	rpm		
14.6	Vibration amplitude at the shaft	microns		
14.7	Nozzle opening			

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Item No.	Parameter	Units	Contractor's Data	Remarks
i)	at rated speed for no- load condition at rated head of 761.5m	%		
ii)	at full- load condition at rated net head of 761.5 m	%		
iii)	at 110% load condition at net head of 761.5 m	%		
iv)	at 110% load condition at maximum net head of 766.2 m	%		
14.8	Fly wheel effect of turbine rotating parts	kgm²		
14.9	Fly wheel effect required from the generator	kgm²		
14.10	Specific speed per jet of unit at rated net head of 761.5 m with 100% nozzle opening	rpm		
14.11	Critical speed of turbine	rpm		
15	**Weights**			
15.1	Weight of finished-machined runner complete	Kg		
15.2	Weight and designation of heaviest part or assembly of the turbine as prepared for shipment	kg		
15.3	Heaviest turbine assembly to be handled by powerhouse crane during installation	kg		
15.4	Total weight of complete turbine			
i)	Stationary parts	kg		
ii)	Rotating parts	kg		
15.5	Heaviest pieces for erection- Distributor	kg		
16	**Make and Type**			
16.1	Pressure Gauge & pressure switches			
16.2	Pressure Transducer			
16.3	Electromagnetic type Flow Indicator			
16.4	Dial type thermometer			
16.5	Resistance temperature detector			
16.6	Moisture detector			
16.7	Level switches			
17	**Dimensions**			
17.1	Maximum diameter, length and designation of turbine part to be removed through generator stator bore.			

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Item No.	Parameter	Units	Contractor's Data	Remarks
17.2	Maximum transportation dimension (L x W x H) and designation of turbine part to be transported	mm x mm x mm		
17.3	Minimum distance between center lines of adjacent units	Mm		
17.4	Recommended setting elevation	m		
17.5	Turbine shaft diameter	mm		
17.6	Length of Turbine shaft	mm		
18	**Turbine discharge flow meter**			
18.1	Type			
18.2	Make			
18.3	Range of flow measurement	m^3/sec		
18.4	Accuracy	%		
19	**Lubricating Oil**			
19.1	Grade & conforming standard			
19.2	Make			
19.3	Equivalent			
19.4	Quantity	L		
20	**Inspection Platform Runner**			
20.1	Elevation	m.		
20.2	Material			
21	**Trolley for Runner Removal**			
21.1	Make and type			
21.2	Height of Runner and Trolley	mm		
22	**Instrumentation (following details for each type of instrument to be furnished)**			
22.1	Make			
22.2	Details of sensor			
i)	Make & type			
ii)	Principle of operation			
22.3	Details of indicating instrument/controller			
i)	Make & type			
ii)	Analogue or digital or LED			
iii)	Level switches for control			
iv)	Auxiliary level switch for alarm			

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Item No.	Parameter	Units	Contractor's Data	Remarks
v)	Output for data acquisition system			
vi)	Input voltage	Volt		
vii)	Special cables			
viii)	Type			
ix)	No. of cores	Nos.		
x)	Size	mm		
xi)	Screening			
22.4	Vibration detector			
i)	Make			
ii)	Type			
iii)	Locations			
23	**Expected life of HP-HVOF coating**			
23.1	Approximate hard coating surface area in accordance to PTS			
i)	Nozzle	m^2		
ii)	Runner	m^2		
iii)	Needle servomotor	m^2		
iv)	Deflector	m^2		
24	Expected silt concentration value up to which turbine can operate with normal wear & tear	ppm		
25	Forbidden zone of operation, if any Range	MW-MW		
26	**Floor/ Hatch Grating**			
26.1	Type			
26.2	Design standard			
26.3	Material and Material standard			
27	**Over speed Device**			
27.1	Mechanical			
i)	Type			
ii)	Make			
27.2	Electrical			
i)	Type			
ii)	Make			
27.3	Hydraulic			
i)	Type			

Item No.	Parameter	Units	Contractor's Data	Remarks
ii)	Make			
28	**Online silt measuring instrument**			
28.1	Type and operating principle			
28.2	Make			
28.3	Accuracy	%		
29	**Ultrasonic on- line flow measurement system**			
29.1	Type			
29.2	Make			
29.3	Minimum no. of paths			
29.4	Accuracy			

2.1.3 Recommended Additional Spare Parts

List hereunder the spare parts which are recommended by the Contractor for purchase in addition to the mandatory spare parts as per Chapter-1 of Volume IV, Section 7. The purchase of any or all of the recommended spare parts will be at the option of KHPL. The prices for recommended additional spare parts for five (5) years shall be quoted separately in the format provided in the Price Schedule (Volume 3).

Item	Description	Make/Type	Quantity
1			
2			
3			
4			

* Use additional sheets if required

2.1.4 Information to be supplied together with the Bid

At least the information listed hereunder shall be given by the Bidder. The Bidder may submit additional documents /descriptions to describe special technical features of offered equipment / system:

i) Compute pressure rise at turbine inlet under the most unfavorable conditions (load acceptance and rejection) as requested in technical specification. Conditions considered as well as governor acting times to be clearly indicated in the computations.

ii) Compute turbine speed rise under conditions as above and for following load rejection parameters.

a) From 110 % rated output to zero

b) From 100 % rated output to zero

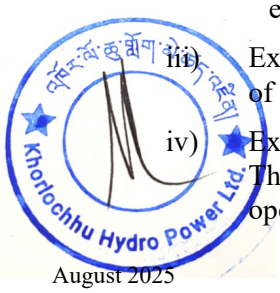
c) From 75 % rated output to zero

d) From 50 % rated output to zero

e) From 25 % rated output to zero

iii) Expected flow characteristics during closing and opening of nozzles as function of time.

iv) Expected performance curves for the maximum, rated and minimum net heads. The curves shall also show the overload output at maximum possible nozzle opening extending beyond the guarantee points.



v) Provide dimensional drawing (cross section) of turbine and associated equipment showing main dimensions.

vi) Describe proposed shaft seal systems preferably illustrated by schematic diagram with detail computational flow analysis and calculation.

vii) Applicable methods and types of vibration monitoring system.

viii) Provide information on model or field performance tests performed on a turbine which is hydraulically similar to the proposed turbine. Indicate at least the following:

a) Place of model or field tests

b) Year of model or field tests

c) Designed rated turbine output

d) Rated net head

e) Rated speed

f) Efficiency achieved

ix) Calculation sheet for dimensions of turbine, generator and powerhouse.

x) Calculation sheet of various heads like, rated net head, maximum net head and minimum net head.

xi) Drawings of cross-section of machine including turbine and complete powerhouse.

xii) Complete details of tools in accordance of technical specifications.

2.1.5 Lists of Tools & Instruments

List of tools and instruments in accordance to the clause 1.15 of PTS Chapter-1 under Section-7 of Volume-4 shall be listed below in additional to the list provided by the employer.

Sl. No	Item/Description	Quantity offered
1	Assembly & erection tools	
2	Testing & Commissioning tools	
3	Testing and Commissioning instruments & devices	
4	Special tools & devices needed for routine maintenance purposes	

2.1.6 Similar Installations (in last 20 years) by the Contactor

Sl. No	Description	Name of owner/utility	Quantity supplied	Year of supply/ commissioning

2.2 Digital Governing System and Accessories

2.2.1 Guaranteed Technical Particulars

Item No.	Parameter	Units	Contractor's Data	Remarks
1	**General**			
1.1	Manufacturer/Place of manufacture			
i)	Control unit			
ii)	Hydraulic Unit			
1.2	Type / designation			
i)	Control unit			
ii)	Hydraulic unit			
1.3	Applicable standards			
2	**Performance Data**			
2.1	Speed stability index	%		
2.2	Power stability index	%		
2.3	Maximum speed rise on full load rejection (% of rated speed)	%		
2.4	Maximum dynamic pressure on total load rejection	kg/cm^2		
2.5	Speed control range	%		
2.6	Range of closing time to limit the guaranteed speed rise and pressure rise	sec		
2.7	Minimum time from spinning of machine to 100% loading	sec		
3	**Characteristic Data**			
3.1	Range of adjustment of permanent speed droop	%		
3.2	Range of adjustment of temporary speed droop	%		
3.3	Sensitivity of governor to respond to minimum speed change of rated speed	%		
3.4	Range of adjustment of governor opening time	sec		
3.5	Speed dead band	%		
3.6	Range of speed measurement	%		
3.7	Governor dead time	sec		
3.8	Frequency dead band range	Hz		
3.9	Speed changer adjustable range (no load)	%		
3.10	Speed changer time setting	sec		

Item No.	Parameter	Units	Contractor's Data	Remarks
3.11	Power changer adjustable range	%		
3.12	Power changer time setting	sec		
3.13	Opening gate limiter time setting	sec		
3.14	Digital Controller			
i)	Type			
ii)	Proportional gain range			
iii)	Integral gain range			
iv)	Derivative gain range			
v)	Is feed forward or ramper device provided	Yes/No		
vi)	Is fully redundant digital electronic controller provided	Yes/No		
3.15	Failure detection feature	Yes/No		
3.16	Hydraulic actuator			
i)	Actuator type			
ii)	Filtering capability of clean filter in pilot oil circuit	microns		
3.17	Oil pumping unit			
i)	Operating oil pressure minimum/rated/maximum	kg/cm^2		
ii)	Volume of oil pressure tank	m^3		
iii)	Number of closing opening operations possible at minimum oil pressure without the operation of oil pump and dry nitrogen admission	C+O		
iv)	Unit governor oil pump discharge at operating pressure of OPU	Lpm		
v)	Jockey pump discharge at operating pressure of OPU	Lpm		
vi)	Maximum oil velocity in pressure pipes	m/s		
vii)	Maximum oil velocity in return pipes	m/s		
viii)	Type of pressure switches			
3.18	Transducers/sensors			
i)	Type of transducer for position feedback			
ii)	Is redundant position feedback provided	Yes/No		
iii)	Is position feedback mismatch detection function provided	Yes/No		
iv)	Nonlinearity of linear position transducer			

Item No.	Parameter	Units	Contractor's Data	Remarks
v)	Type of speed sensing			
vi)	Type of transducer for speed feed back			
vii)	Resolution of speed measurement			
viii)	Speed measurement range			
ix)	Type of mechanical over speed device			
3.19	Provision of emergency control	Yes/No		
3.20	Type of emergency valve			
3.21	Hydraulic oil			
i)	Oil quality (grade/standard)			
3.22	Governor operation in restricted governing mode (RGMO)	Yes/No		
3.23	Governor operation in condenser mode	Yes/No		
3.24	Time of deflector to cut off the jet from runner under full load	sec		
3.25	Islanded and Isolated Mode of Operation	Yes/No		
3.26	Communication protocol compatibility with IEC 61850/IEC 60870-5-104	Yes/No		

2.2.2 Informative Data

Item No.	Parameter	Units	Contractor's Data	Remarks
1	**Accumulator**			
1.1	Height	mm		
1.2	Diameter	mm		
1.3	Normal volume of oil in pressurized tank	L		
2	**Oil sump tank**			
2.1	Length x width x depth	mm x mm x mm		
2.2	Total oil volume	L		
3	**Oil pumps**			
3.1	Number of main oil pumps	Nos.		
3.2	Type of oil pumps			
3.3	Unit governor oil pump discharge	Lpm		
3.4	Working pressure	kg/cm^2		
4	**Transducers**			
4.1	Position transducer			
i)	Make			
ii)	Type			
iii)	Accuracy	%		
iv)	Location			

Item No.	Parameter	Units	Contractor's Data	Remarks
4.2	Frequency/Speed transducer			
i)	Make			
ii)	Type			
iii)	Accuracy	%		
iv)	Location			
4.3	Power transducer			
i)	Make			
ii)	Type			
iii)	Accuracy	%		
iv)	Location			
5	**Special cables**			
5.1	Type			
5.2	No. Of cores	Nos.		
5.3	Size	mm^2		
5.4	Screening			
6	**Nitrogen Bottles**			
6.1	Make			
6.2	Type			
6.3	Numbers of bottles per bank			
6.4	Maximum pressure	kg/cm^2		
6.5	Total volume	m^3		
7	**Weight**			
7.1	Accumulator			
i)	With oil	kg		
ii)	Without oil	kg		
7.2	Oil sump tank			
i)	With oil	kg		
ii)	Without oil	kg		
8	**Material grade/ type and standards**			
8.1	Oil pipes			
8.2	Servomotor cylinder body			
8.3	Servomotor piston			
8.4	Nitrogen bottles body			
9	**Pressure switches**			
9.1	Type/make			
9.2	Auxiliary voltage			
9.3	Number of contacts			
10	**Speed relays**			
10.1	Type/make			
10.2	Adjustable range			
10.3	Pick-up/drop-off ratio			
10.4	Number of contacts			

2.2.3 Recommended Additional Spare Parts

List hereunder the spare parts which are recommended by the Contractor for purchase in addition to the mandatory spare parts as per Chapter-2 of Volume IV, Section 7. The purchase of any or all of the recommended spare parts will be at the option of KHPL. The

prices for recommended additional spare parts for five (5) years shall be quoted separately in the format provided in the Price Schedule (Volume 3).

Item	Description	Make/Type	Quantity
1			
2			
3			
4			

* Use additional sheets if required

2.2.4 Information to be supplied together with the Bid

At least the information listed hereunder shall be given by the Bidder. The Bidder may submit additional documents /descriptions to describe special technical features of offered equipment / system:

i) Description of the governor, including schematic and block diagrams.

ii) Drawings showing overall dimensions and general arrangement of equipment.

iii) Description and technical data of the programmable, numerical type control unit.

iv) Applicable method and type of speed sensing equipment.

v) Explanations of fail-safe provisions according to Technical specification.

vi) Details on the operating time adjustment for nozzle & deflector servomotor closing and opening (refer to Technical specification).

vii) Details of all types of transducers including principle of operation, accuracy and other characteristics.

viii) Details of all types of indicators on different panels.

ix) Details of accumulator unit.

2.2.5 Lists of Tools & Instruments

List of tools and instruments in accordance to the clause 2.13 of PTS Chapter-2 under Section-7 of Volume-4 shall be listed below in additional to the list provided by the employer.

Sl. No	Item/Description	Quantity offered
1	Assembly & erection tools	
2	Testing & Commissioning tools	
3	Testing and Commissioning instruments & devices	
4	Special tools & devices needed for routine maintenance purposes	

2.2.6 Similar Installations (in last 20 years) by the Contactor

Sl. No	Description	Name of owner/utility	Quantity supplied	Year of supply/ commissioning

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2.3 Main Inlet Valves and Accessories

2.3.1 Guaranteed Technical Particulars

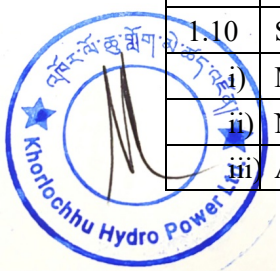
Item No.	Parameter	Units	Contractor's Data	Remarks
1	**General**			
1.1	Manufacturer/place of manufacturing			
1.2	Type /designation			
1.3	Applicable standard			
2	**Main Data**			
2.1	Main dimensions of valve			
i)	Inside diameter	mm		
ii)	Dimensions of valve			
a)	Flange to flange	mm		
b)	Trunnion to trunnion	mm		
2.2	Valve operating oil pressure			
i)	Minimum	kg/cm^2		
ii)	Maximum	kg/cm^2		
2.3	Maximum leakage from main inlet valve when fully closed against maximum gross head			
i)	Through service seal	lpm		
ii)	Through maintenance seal	lpm		
iii)	Through bypass valve	lpm		
2.4	Maximum head loss through the valve at a flow required for rated turbine output at Design head	m		
2.5	Capability of the valve to open at 50 % unbalance condition	Yes/No		
2.6	Capability of the valve to close at maximum flow rate and maximum gross head by action of counter weights	Yes/No		
2.7	Lowest factor of safety (referred to design stress) for any hydraulically loaded part of the valve			
2.8	Number of closing - opening operations possible at minimum oil pressure without the operation of oil pump and dry nitrogen admission	C+O		
2.9	Design pressure for Main inlet Valve	kg/cm^2		

2.10	Corrosion and abrasion allowance for valve components	mm		
2.11	Material standard, class, grade/type			
i)	Valve body			
ii)	Valve rotor/plug			
iii)	Valve trunnions			
iv)	Sleeve			
v)	Permanent seat of seals, seal retainers and fasteners			
vi)	Service seal			
vii)	Maintenance seal			
viii)	Oil pressure piping			

2.3.2 Informative Data

Item No.	Parameter	Units	Contractor's Data	Remarks
1	**Main data**			
1.1	Closing time under			
i)	No flow	sec		
ii)	Design discharge of turbine	sec		
iii)	Maximum possible discharge of turbine	sec		
1.2	Opening time under			
i)	No pressure/head	sec		
ii)	Design head	sec		
iii)	Maximum gross head	sec		
1.3	By-pass valve closing time at			
i)	No flow	sec		
ii)	Design discharge of by-pass valve	sec		
1.4	By-pass valve opening time at			
i)	No pressure/head	sec		
ii)	Design head	sec		
iii)	Maximum gross head	sec		
1.5	Maximum torque required to close the valve with a flow corresponding to;			
i)	Rated turbine output at Design head	Nm		
ii)	Maximum gate output at Design head	Nm		
iii)	Rated turbine output at gross head	Nm		
iv)	Turbine over load at maximum head	Nm		
v)	Maximum torque required to close the valve in any other worst possible condition	Nm		

Item No.	Parameter	Units	Contractor's Data	Remarks
1.6	Oil pressure unit (OPU)			
i)	Pressure Accumulator			
a)	Type			
b)	Design oil pressure	kg/cm^2		
c)	Total oil volume	litre		
d)	Dimensions (Height X diameter)	mm x mm		
e)	Type of pressure switches			
ii)	Sump tank			
a)	Total oil volume	Litre		
b)	Dimension (lxwxh)	mmxm mxmm		
iii)	Oil pumps			
a)	Number of main oil pumps	Nos.		
b)	Type of oil pumps			
c)	Oil pump discharge capacity	Lpm		
d)	Oil pump discharge at pressure	bars		
e)	Power rating of main pump motor	kW		
f)	Duty class of the main pump motor			
iv)	Jockey pump provided	Yes/ NO		
a)	Type of jockey pump			
b)	Jockey pump discharge capacity	Lpm		
c)	Jockey pump discharge at pressure	kg/cm^2		
d)	Power rating of Jockey pump	kW		
e)	Duty class of the Jokey pump motor			
1.7	Nitrogen Bottles			
i)	Make			
ii)	Type			
iii)	Numbers of bottles			
iv)	Maximum pressure	kg/cm^2		
v)	Total volume	m^3		
1.8	Total quantity of hydraulic oil required for complete system including servomotor	Litre		
1.9	Oil quality (Grade/ Standard)			
1.10	Servomotor			
i)	Make			
ii)	Nominal design oil pressure	kg/cm^2		
iii)	Active volume	m^3		



Item No.	Parameter	Units	Contractor's Data	Remarks
1.11	Maximum distance from horizontal centre line of valve			
i)	Valve pedestal	mm		
ii)	Servomotor foundation	mm		
2	**Weights**			
2.1	W eight of complete shut off valve	kg		
2.2	Estimated shipping weight of valve	kg		
2.3	Maximum weight of valve assembly to be handled by Power House crane	kg		
2.4	Name and size of the largest component to be handled by the EOT crane	mm x mm x mm		
3	**Material grade/type and standards**			
3.1	Servomotor cylinder body			
3.2	Counter weight			
3.3	Nitrogen Bottles body			
3.4	OPU sump tank and accumulator			
4	**Service and maintenance seals**			
4.1	Interchangeability of service and maintenance seal	Yes/No		

2.3.3 Recommended Additional Spare Parts

List hereunder the spare parts which are recommended by the Contractor for purchase in addition to the mandatory spare parts as per Chapter-3 of Volume IV, Section 7. The purchase of any or all of the recommended spare parts will be at the option of KHPL. The prices for recommended additional spare parts for five (5) years shall be quoted separately in the format provided in the Price Schedule (Volume 3).

Item	Description	Make/Type	Quantity
1			
2			
3			
4			

* Use additional sheets if required

2.3.4 Information to be supplied together with the Bid

At least the information listed hereunder shall be given by the Bidder. The Bidder may submit additional documents /descriptions to describe special technical features of offered equipment / system:

i) Description of method of operation of the valve (by oil pressure and counterweight)

ii) Proposed type of by-pass valve.

iii) Description of method of operation of the automatic air inlet and vacuum release valve.

iv) Proposed bearing and seal design.

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v) Dimensional drawing with cross section of the valve showing the valve body sections, type of trunnion seal, bearing, general arrangement of major valve parts and main dimensions.

vi) Schematic hydraulic diagram of complete main inlet valve system with description.
vii) Curves for valve head losses.
viii) Expected maximum dynamic and static loads on foundation for the most unfavorable conditions (opening/closure).
ix) Proposed erection method and handling by EOT crane with diagram.

2.3.5 Lists of Tools & Instruments

List of tools and instruments in accordance to the clause 3.13 of PTS Chapter-3 under Section-7 of Volume-4 shall be listed below in additional to the list provided by the employer.

Sl. No	Item/Description	Quantity offered
1	Assembly & erection tools	
2	Testing & Commissioning tools	
3	Testing and Commissioning instruments & devices	
4	Special tools & devices needed for routine maintenance purposes	

2.3.6 Similar Installations (in last 20 years) by the Contactor

Sl. No	Description	Name of owner/utility	Quantity supplied	Year of supply/ commissioning

2.4 Butterfly Valve and Accessories

2.4.1 Guaranteed Technical Particulars

Item No.	Parameter	Units	Contractor's Data	Remarks
1	**General**			
1.1	Manufacturer/place of manufacture			
1.2	Type /designation			
1.3	Applicable standard			
2	**Main Data**			
2.1	Main dimensions of valve			
i)	Inside diameter	mm		
ii)	Dimensions of valve			
a)	Flange to flange	mm		
b)	Trunnion to trunnion	mm		
2.2	Valve operating oil pressure			
i)	Minimum	kg/cm^2		
ii)	Maximum	kg/cm^2		
2.3	Maximum leakage from main inlet valve when fully closed against maximum gross head			
i)	Through Service Seal	lpm		
ii)	Through Maintenance Seal	lpm		
iii	Through Bypass Valve	lpm		
2.4	Maximum head loss through the valve at a flow required for rated turbine output at design head	m		
2.5	Capability of the valve to open at 50 % unbalance condition	Yes/No		
2.6	Capability of the valve to close at maximum flow rate and maximum gross head by action of counterweights	Yes/No		
2.7	Lowest factor of safety (referred to design stress) for any hydraulically loaded part of the valve			
2.8	Number of closing - opening operations possible at minimum oil pressure without the operation of oil pump and dry nitrogen admission	C+O		
2.9	Design pressure for Butterfly Valve	kg/cm^2		
2.10	Corrosion and abrasion allowance for valve components	mm		
2.11	Material standard, class, grade/type of			
i)	Valve body			
ii)	Valve disc			

Item No.	Parameter	Units	Contractor's Data	Remarks
iii	Valve trunnions			
iv	Sleeve			
v)	Permanent seat of seals, seal retainers and fasteners			
vi	Service seal			
vii	Maintenance seal			
vii	Oil pressure piping			

2.4.2 Informative Data

Item No.	Parameter	Units	Contractor's Data	
1	**Main data**			
1.1	Closing time under			
i)	No flow	sec		
ii)	Design discharge of turbine	sec.		
iii)	Maximum possible discharge of turbine	sec		
1.2	Opening time under			
i)	No pressure/head	sec		
ii)	Design head	sec		
iii)	Maximum gross head	sec		
1.3	By-pass valve closing time at			
i)	No flow	sec		
ii)	Design discharge of by-pass valve	sec		
1.4	By-pass valve opening time at			
i)	No pressure/head	sec		
ii)	Design head	sec		
iii)	Maximum gross head	sec		
1.5	Maximum torque required to close the valve with a flow corresponding to			
i)	Rated turbine output at Design head	Nm		
ii)	Maximum gate output at design head	Nm		
iii)	Rated turbine output at gross head	Nm		
iv)	Turbine over load at maximum head	Nm		
v)	Maximum torque required to close the valve in any other worst possible condition	Nm		
1.6	Oil pressure unit (OPU)			
i)	Pressure Accumulator			
a)	Type			
b)	Design oil pressure	kg/cm^2		
c)	Total oil volume	litre		
d)	Dimensions (Height X diameter)	mm x mm		
e)	Type of pressure switches			
ii)	Sump tank			
a)	Total oil volume	Litre		
b)	Dimension (LXW XH)	mm x mm x mm		
iii)	Oil pumps			
a)	Number of main oil pumps	Nos.		

Item No.	Parameter	Units	Contractor's Data	
b)	Type of oil pumps			
c)	Oil pump discharge capacity	Lpm		
d)	Oil pump discharge at pressure	kg/cm^2		
e)	Power rating of main pump motor	kW		
f)	Duty class of the main pump motor			
g)	Type of jockey pump			
h)	Jockey pump discharge capacity	Lpm		
i)	Jockey pump discharge at pressure	kg/cm^2		
j)	Power rating of Jockey pump	kW		
k)	Duty class of the Jokey pump motor			
1.7	Nitrogen Bottles			
i)	Make			
ii)	Type			
iii)	Numbers of bottles			
iv)	Maximum pressure	kg/cm^2		
v)	Total volume	m^3		
1.8	Total quantity of hydraulic oil required for complete system including servomotor	Litre		
1.9	Oil quality (Grade/ Standard)			
1.10	Servomotor			
i)	Make			
ii)	Nominal design oil pressure	kg/cm^2		
iii)	Active volume	m^3		
1.11	Maximum distance from horizontal Centre line of valve to			
i)	Valve pedestal	mm		
ii)	Servomotor foundation	mm		
2	**Weights**			
2.1	W eight of complete shut off valve	kg		
2.2	Estimated shipping weight of valve	kg		
2.3	Maximum weight of valve assembly to be handled by crane	kg		
2.4	Name and size of the largest component to be handled by the EOT crane	mm x mm x mm		
3	**Material grade/type and standards**			
3.1	Servomotor cylinder body			
3.2	Counter weight			
3.3	Nitrogen Bottles body			
3.4	OPU sump tank and accumulator			

2.4.3 Recommended Additional Spare Parts

List hereunder the spare parts which are recommended by the Contractor for purchase in addition to the mandatory spare parts as per Chapter-4 of Volume IV, Section 7. The purchase of any or all of the recommended spare parts will be at the option of KHPL. The prices for recommended additional spare parts for five (5) years shall be quoted separately in the format provided in the Price Schedule (Volume 3).

Item	Description	Make/Type	Quantity
1			
2			
3			
4			

* Use additional sheets if required

2.4.4 Information to be supplied together with the Bid

At least the information listed hereunder shall be given by the Bidder. The Bidder may submit additional documents /descriptions to describe special technical features of offered equipment / system:

i. Description of method of operation of the valve (by oil pressure and counterweight)

ii. Proposed type of by-pass valve.

iii. Description of method of operation of the automatic air inlet and vacuum release valve.

iv. Proposed bearing and seal design.

v. Dimensional drawing with cross section of the valve showing the valve body sections, type of trunnion seal, bearing, general arrangement of major valve parts and main dimensions.

vi. Schematic hydraulic diagram of complete main inlet valve system with description.

vii. Curves for valve head losses.

viii. Expected maximum dynamic and static loads on foundation for the most unfavorable conditions (opening/closure).

ix. Proposed erection method and handling by EOT crane with diagram.

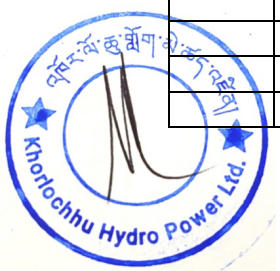
2.4.5 Lists of Tools & Instruments

List of tools and instruments in accordance to the clause 4.13 of PTS Chapter-4 under Section-7 of Volume-4 shall be listed below in additional to the list provided by the employer.

Sl. No	Item/Description	Quantity offered
1	Assembly & erection tools	
2	Testing & Commissioning tools	
3	Testing and Commissioning instruments & devices	
4	Special tools & devices needed for routine maintenance purposes	

2.4.6 Similar Installations (in last 20 years) by the Contactor

Sl. No	Description	Name of owner/utility	Quantity supplied	Year of supply/ commissioning



2.5 Generator and Accessories

2.5.1 Guaranteed Technical Particulars

Item No.	Parameter	Units	Contractor's Data
1	**General**		
1.1	Manufacturer/place of manufacture		
1.2	Type/ designation		
1.3	Applicable standards		
2	**Performance data**		
2.1	Generator rated power at rated frequency and voltage		
i)	At 0.9 power factor (lagging)	MVA	
ii)	At unity power factor	MVA	
2.2	Generator maximum power at rated frequency/voltage and 0.9 power factor	MVA	
2.3	Weighted average efficiency(according to the particular technical specification)	%	
2.4	Corresponding average generator total losses	kW	
2.5	Design runaway speed	RPM	
2.6	Allowable over speed	RPM	
2.7	Runaway speed withstand time	Sec.	
2.8	Lowest factor of safety (referred to yield strength) for a generator rotating part at runaway speed		
2.9	Maximum peripheral speed at runaway speed	m/s	
2.10	Capability of bearings to withstand		
i)	Runaway speed with cooling water	Min	
ii)	Rated speed without cooling water	Min	
iii)	Runaway speed without cooling water	Min	
3	**Characteristic data**		
3.1	No. of phases	Nos.	
3.2	Rated power factor lagging	-	
3.3	Generator rated voltage	kV	
3.4	Guaranteed voltage range	%	
3.5	Generator losses at full load, rated voltage and rated power factor:		
i)	Constant losses	kW	
ii)	Load losses	kW	
3.6	Rated frequency	Hz	
3.7	Guaranteed frequency range	%	
3.8	Rated synchronous speed	rpm	
3.9	Direction of rotation (viewed from top)	CW /CCW	
3.10	Flywheel effect of the generator rotating parts, excluding turbine wheel at overload output		
	Inertia constant (H)	kW-sec/ kVA	
3.11	Temperatures		
i)	Maximum generator temperature rise above ambient air temperature with the generator delivering maximum rated output continuously while operating at rated power factor over the		

Item No.	Parameter	Units	Contractor's Data
	range of 90% to 110% of rated voltage and 95% - 105% of rated frequency:		
a)	stator winding, measured by RTD	°C	
b)	field winding, measured by resistance method	°C	
ii)	Maximum temperature with the Generator delivering maximum rated output continuously:		
a)	Thrust bearing pad, measured by embedded temperature detector	°C	
b)	Guide bearing segments, measured by embedded temperature detector	°C	
iii)	Temperature limit assigned by the Bidder to the generator:		
a)	Stator winding insulation	°C	
b)	Field winding insulation	°C	
3.12	Generator short-circuit ratio	-	
3.13	Excitation conditions		
i)	Maximum admissible continuous generator output when charging a transmission line under-excited without the generator becoming unstable or self-excited, at rated frequency and rated voltage	MVAR	
ii)	Maximum admissible continuous generator output when operating as synchronous condenser, over-excited, at rated frequency and voltage	MVAR	
iii)	Ratings of field winding at nominal operating conditions of generator (corrected for 75°C winding temperature)		
iv)	Field current	A	
v)	Field voltage	V	
4	**Weight**		
4.1	Weight of the generator rotating parts including shafts	kg	
4.2	Weight of the heaviest assembly or part of the generator to be lifted by the powerhouse crane, including necessary lifting beam as prepared for shipment	kg	
5	**Dimensions**		
5.1	Minimum required crane hook clearance above machine hall floor elevation, including necessary lifting beam for erection, dismantling or maintenance of the generator by means of the power house crane	mm	
5.2	Overall dimension and weight of largest generator part or assembly, as prepared for shipment		
i)	Name		
ii)	Length	mm	
iii)	Height	mm	
iv)	Width	mm	
v)	Weight	kg	
6	**Material standard, Class, Grade/Type of**		
6.1	Stator frame		
6.2	Stator core		
6.3	Stator coil		

Item No.	Parameter	Units	Contractor's Data
6.4	Rotor spider		
6.5	Rotor rim		
6.6	Rotor pole lamination		
6.7	Rotor pole coil		
6.8	Brake ring		
6.9	Bearing pad lining		
6.10	Generator shaft		
6.11	Coupling bolts		
6.12	Bearing housing		
6.13	Pressure Pipes		
6.14	Cooler tubes		
6.15	Fasteners on parts requiring frequent dismantling.		
6.16	All embedded pipes relating to Generating units and auxiliaries.		
6.17	Supports, brackets and components		
6.18	Type of lower guide bearing		
6.19	Type of upper guide bearing and thrust bearing		
6.20	Carbon dust collector		
6.21	Brake dust collector		
7	Interval of overhauling of generator and turbine shaft for bearing settings, unit leveling, centering and alignment, etc.	Years	
8	Oil leakages from vapor seals/oil retaining sleeves of upper and lower guide bearing housings/brackets	Yes/No	
9	Machine speed at which dynamic braking is applied	rpm	
10	Generator operation in condenser mode	Yes/No	

2.5.2 Informative Data

Item No.	Parameter	Units	Contractor's Data
1	**General**		
1.1	Compatibility with Plant SCADA system		
i)	Generator control and monitoring	Yes / No	
ii)	On-line monitoring systems	Yes / No	
2	**Generator efficiency**		
2.1	Generator efficiency at rated voltage, frequency and rated power factor		
i)	At 110 % continuous rated output (MVA)	%	
ii)	At 100 % continuous rated output (MVA)	%	
iii)	At 75 % continuous rated output (MVA)	%	
iv)	At 50% continuous rated output	%	
3	**Generator time constants**		

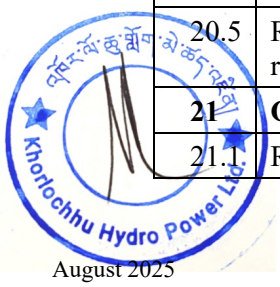
Item No.	Parameter	Units	Contractor's Data
3.1	direct axis, open circuit transient time constant (T'do)	sec.	
3.2	direct axis, short-circuit transient time constant (T'd)	sec.	
3.3	armature short-circuit time constant (Ta)	sec.	
3.4	Quadrant axis transient short circuit time constant	sec.	
3.5	Direct axis-sub transient open circuit time constant	sec.	
4	**Electrical characteristics**		
4.1	Maximum value of three phase Symmetrical short circuit current (rms) when m/c is delivering rated output at 0.9p.f. under voltage regulator control		
i)	Peak	kA	
ii)	RMS	kA	
4.2	Maximum duration of short circuit which the generator can withstand without any damage	sec.	
4.3	Deviation factor of wave form, measured in % from line to line on open circuit at rated voltage and frequency		
4.4	Telephone harmonic factor	%	
4.5	Generator synchronous reactance:		
i)	Direct axis(xd)	p.u.	
ii)	Quadrature axis(xq)	p.u.	
4.6	Generator transient reactance:		
i)	Direct axis(x'd)	p.u.	
ii)	Quadrature axis(x'q)	p.u.	
4.7	Generator sub transient reactance:		
i)	Direct axis(x''d)	p.u.	
ii)	Quadrature axis(x''q)	p.u.	
4.8	Generator negative phase sequence reactance	p.u.	
4.9	Generator zero phase sequence reactance	p.u.	
4.10	Armature leakage reactance (xl)	p.u	
4.11	Resistance of		
i)	Armature winding per phase at 75°C	ohm	
ii)	Field winding at 75°C	ohm	
iii)	Damper winding along D-axis	ohm	
iv)	Damper winding along Q-axis	ohm	
4.12	Maximum unbalance force with sequence of 50 % rotor pole short circuited	kg-f	
5	**Dimensions**		

Item No.	Parameter	Units	Contractor's Data
5.1	Inner diameter of generator barrel	mm	
5.2	Diameter of stator frame	mm	
5.3	Generator stator bore, diameter	mm	
5.4	Generator effective core length	mm	
5.5	Diameter of rotor	mm	
5.6	Air gap between rotor and stator	mm	
6	**Maximum expected current density (nominal operation)**		
6.1	Stator winding	A/mm^2	
6.2	Field winding	A/mm^2	
7	**Capacitance per phase to ground of stator winding**	µF	
8	**Generator rotor**		
8.1	OD of rotor	mm	
8.2	Type of rotor rim	-	
8.3	Class of insulation of field winding	-	
8.4	Factor of safety at maximum speed based on yield point of the material		
8.5	Type of collector ring brushes	-	
8.6	No. of brushes on collector ring		
8.7	Accepted tolerance levels for alignment of shaft	mm	
9	**Generator Braking/ Jacking System**		
9.1	No. of braking cylinders	Nos.	
9.2	Size of brake/jack units (dia. X height)	mm x mm	
9.3	Speed at which brakes may be applied		
i)	In normal operation	rpm	
ii)	In emergency operation	rpm	
9.4	Braking time for the above conditions for bringing the machine to rest.		
i)	In normal operation	sec.	
ii)	In emergency operation	sec.	
9.5	Air requirement for one brake application		
i)	Pressure	bars	
ii)	Quantity	m^3	
10	**Coolers**		
10.1	No. of Air-water Heat-exchangers (stator Air Coolers)	Nos.	
10.2	No. of thrust bearing oil coolers	Nos.	
10.3	No. of guide bearing oil coolers	Nos.	

Item No.	Parameter	Units	Contractor's Data
10.4	Cooling water pressure required for above coolers	bars	
10.5	Chemical composition of cooling tubes (Cu:Ni)	%	
11	**Mixing/three way diverting valve (self-operated temperature regulated)**		
11.1	Manufacturer/place of manufacturer		
11.2	Type/designation		
11.3	Applicable standard		
12	**Quantity of cooling water required**		
12.1	Air coolers, total	L/s	
12.2	Thrust & Upper guide bearing oil cooler (total)	L/s	
12.3	lower guide bearing oil cooler (total)	L/s	
13	**Fire Protection System**		
13.1	Water quantity required for fire fighting	L/s	
13.2	For duration of	sec.	
13.3	Water pressure requirement	bars	
14	**Thrust Bearing**		
14.1	Total load on thrust bearing, including rotating turbine parts and hydraulic thrust	kN	
14.2	Number of thrust bearing pads	Nos.	
14.3	Specific load on thrust bearing at nominal operation	N/mm^2	
14.4	Total load on T.B. including hydraulic thrust	kg	
14.5	Effective bearing surface area	m^2	
14.6	Lift of Rotor due to H.S. lubrication	mm	
14.7	Diameter of thrust bearing rotating disc	mm	
14.8	Oil required to fill thrust bearing	L	
14.9	Rating of motor for thrust bearing high pressure hydrostatic oil pump		
i)	AC	kW	
ii)	DC	kW	
15	**Guide Bearing**		
15.1	Location and number	-	
15.2	Type	-	
15.3	No. of pads in each bearing	Nos.	
15.4	Effective surface area of each guide bearing	m^2	
15.5	Oil required to fill guide bearing	L	
16	**Generator Stator**		
16.1	Number of sections into which the generator stator is divided (for transportation)	Nos.	
16.2	Class of Insulation		

Item No.	Parameter	Units	Contractor's Data
16.3	Generator space heaters		
i)	No. Of units	Nos.	
ii)	Rating of units	kW	
16.4	Thickness of stator magnetic Lamination (tolerance %)	mm	
17	**Brackets**		
17.1	Number of arms of lower bracket	Nos.	
17.2	Number of arms of upper bracket	Nos.	
18	**Segregated losses at nominal operating conditions**		
18.1	Constant losses		
18.1.1	Core losses	kW	
18.1.2	Ventilation losses	kW	
18.1.3	Friction losses in lower guide bearing	kW	
18.1.4	Friction losses in thrust and upper guide bearing		
i)	Total losses caused by generator rotor , turbine runner & hydraulic thrust	kW	
ii)	Losses caused by the generator rotor only	kW	
18.2	Load losses		
i)	I^2R losses in armature winding including additional losses (corrected for 75^0 C)	kW	
ii)	I^2R losses in field winding (corrected for 75^0 C)	kW	
18.3	Excitation losses	kW	
18.4	Additional losses (if any)	kW	
18.5	Total losses	kW	
19	**On line safety/monitoring devices**		
19.1	Vibration monitoring system		
i)	Make		
ii)	Points monitored and number of sensors		
iii)	Type of sensor		
iv)	Whether details of system attached	Yes/No	
v)	Communication protocol on IEC 61850/IEC 60870-5-104	Yes/No	
vi)	Applicable Standards		
19.2	Air Gap monitoring system		
i)	Make		
ii)	Points monitored and number of sensors		
iii)	Type of sensor		
iv)	Whether details of system attached	Yes/No	
v)	Communication protocol on IEC 61850/IEC 60870-5-104		

Item No.	Parameter	Units	Contractor's Data
vi)	Applicable Standards		
19.3	Partial discharge analyser		
i)	Make		
ii)	Points monitored and number of sensors		
iii)	Type of sensor		
iv)	Whether details of system attached	Yes/No	
v)	Communication protocol on IEC 61850/IEC 60870-5-104		
vi)	Applicable Standards		
19.4	Moisture detector		
i)	Make		
ii)	Points monitored and number of sensors		
iii)	Type of sensor		
iv)	Whether details of system attached	Yes/No	
v)	Applicable Standards		
19.5	Shaft current , voltage monitoring device		
i)	Make		
ii)	Points monitored and number of sensors		
iii)	Type of sensor		
iv)	Whether details of system attached		
v)	Communication protocol on IEC 61850/IEC 60870-5-104	Yes/No	
vi)	Applicable Standards		
19.6	Temperature monitoring system		
i)	Make		
ii)	Number of channels/points		
iii)	Communication protocol on IEC 61850/IEC 60870-5-104	Yes/No	
iv)	Applicable standard		
20	**Weight**		
20.1	Approximate weight of assembled stator	kg	
20.2	Approximate weight of rotor	kg	
20.3	Net weight of complete generator, including coolers, racks, platform etc. as offered	kg	
20.4	W eight of the lifting beam	kg	
20.5	Recommendation for crane capacity w.r.t. rotor/stator maximum weight to be handled	kg	
21	**Generator Condenser Operation**		
21.1	Rating		



2.5.3 Recommended Additional Spare Parts

List hereunder the spare parts which are recommended by the Contractor for purchase in addition to the mandatory spare parts as per Chapter-5 of Volume IV, Section 7. The purchase of any or all of the recommended spare parts will be at the option of KHPL. The prices for recommended additional spare parts for five (5) years shall be quoted separately in the format provided in the Price Schedule (Section F).

Item	Description	Make/Type	Quantity
1			
2			
3			
4			

* Use additional sheets if required

2.5.4 Information to be supplied together with the Bid

At least the information listed hereunder shall be given by the Bidder. The Bidder may submit additional documents /descriptions to describe special technical features of offered equipment / system:

i) Technical offer
ii) General arrangement drawings
iii) Details of Accessories
iv) Technical Data Sheet / Dully filled Datasheet B
v) Performance curves.
vi) Type test certificates of similar type & rating
vii) Transportation details
viii) Vendor list
ix) Catalogues

2.5.5 Lists of Tools & Instruments

List of tools and instruments in accordance to the clause 5.24 of PTS Chapter-5 under Section-7 of Volume-4 shall be listed below in additional to the list provided by the employer.

Sl. No	Item/Description	Quantity offered
1	Assembly & erection tools	
2	Testing & Commissioning tools	
3	Testing and Commissioning instruments & devices	
4	Special tools & devices needed for routine maintenance purposes	

2.5.6 Similar Installations (in last 20 years) by the Contactor

Sl. No	Description	Name of owner/utility	Quantity supplied	Year of supply/ commissioning

2.6 Excitation System

2.6.1 Guaranteed Technical Particulars

Item No.	Parameter	Units	Contractor's Data
1	**General**		
1.1	Manufacturer/Place of Manufacture		
1.2	Type / designation		
1.3	Applicable standards		
2	**Ratings of excitation system at rated generator output and rated power factor (hot rotor winding)**		
2.1	Field voltage	V	
2.2	Field current	A	
2.3	Field power	kW	
2.4	No load excitation voltage	V	
2.5	No load field current	A	
2.6	Field flashing current and duration	A, sec.	
3	**Data of excitation system at 110% rated generator terminal voltage, power factor 0.9 and maximum generator power**		
3.1	Field voltage	V	
3.2	Field current	A	
4	**Excitation current limits**		
4.1	Continuous load	A	
4.2	Exception load (15 minutes)	A	
4.3	Accidental load (60 seconds)	A	
5	**Positive ceiling voltage in per units of rated field voltage**		
5.1	Positive ceiling voltage at no load	p.u.	
5.2	Positive ceiling voltage at rated load	p.u.	
6	**Negative ceiling voltage in per units of rated field voltage**		
6.1	Negative ceiling voltage at no load	p.u.	
6.2	Negative ceiling voltage at no load	pu	
7	Field current at rated ceiling voltage	A	
8	Excitation system voltage response ratio	V/s	
9	Time to reach +0.5% of ceiling voltage from field voltage	sec.	
10	Maximum time period for operation at ceiling voltage without damage	sec.	
11	Response time	sec	
12	**Maximum continuous output capability of one 100 % excitation system**		
12.1	Maximum field current	A	
12.2	Maximum field voltage	V	
13	Maximum duration of over excitation	sec.	

Item No.	Parameter	Units	Contractor's Data
14	Time to reach 5 % limit of generator terminal voltage in case of load rejection	sec.	
15	Maximum overshoot of generator terminal voltage in case of load rejection	%	
16	Settling time to reach 0.5 % limit of generator terminal voltage after over speed conditions	s	
17	Range of voltage level setting	%	
18	Range for manual control of excitation		
19	**Excitation transformer**		
19.1	Type/designation	-	
19.2	Transformer continuous three-phase power rating	kVA	
19.3	Transformer voltage ratio		
19.4	Transformer total losses (75°C three-phase) at rated voltage and rated frequency		
i)	At no load	kW	
ii)	At rated load	kW	
19.5	Impedance voltage (75^0C) at rated frequency, on 100% rated kVA	%	
19.6	Transformer temperature rise after continuous operation with rated kVA, under rated conditions(by resistance)	°C	
19.7	Transformer rated voltage at rated frequency and no-load		
i)	High-voltage,	kV	
ii)	Low voltage	kV	
iii)	Material of core	-	
iv)	Material of conductor	-	
v)	Class of insulation	-	
vi)	Bil	kV	
20	**Voltage regulating system**		
20.1	Type/designation of DVR	-	
20.2	Accuracy of voltage regulation	%	
20.3	Range of voltage setting	%	
20.4	Voltage regulation from no load to full load	%	
20.5	Whether redundant AVR is provided	Yes/ No	
20.6	Whether manual control of voltage provided	Yes/ No	
21	**Rectifiers**		
21.1	Type of thyristors	-	
21.2	Number of thyristors per interchangeable module	Pcs	

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Item No.	Parameter	Units	Contractor's Data
21.3	Number of modules per bridges or stacks	Pcs	
21.4	Number of bridges or stacks	Pcs	
21.5	Number of parallel paths	Pcs	
21.6	Number of thyristors	Pcs	
21.7	Rated current of rectifier	A	
21.8	Rated Voltage of rectifier	V	
21.9	Average forward current rating for thyristor	A	
21.10	Forward voltage drop for thyristor	V	
21.11	Maximum surge current rating	A	
21.12	Maximum permissible duration of surge current	A	
21.13	Maximum safe operating temperature	°C	
21.14	Cooling fans for rectifiers		
i)	Number of fans	Pcs	
ii)	Fan rating	m^3/min	
21.15	Electrical fan motor ratings		
i)	Rated voltage	V	
ii)	Rated power consumption	kW	
21.16	Peak inverse voltage	V	
22	**Field circuit breaker**		
22.1	Rated current	A	
22.2	Rated voltage	V	
22.3	Rated breaking current	kA	
22.4	Total opening time	sec.	
22.5	Total closing time	sec.	
22.6	Life time (operation at rated capacity)		
23	**AC - Field flashing equipment**		
23.1	Power rating of field flashing transformer	kVA	
23.2	Rated voltages of transformer primary and secondary side	V	
24	**DC - Field flashing equipment**		
24.1	Power requirements	kW	
24.2	Supply voltage	V	
24.3	Duration of flashing	sec	
25	**Field discharge resistor**		
25.1	Type		
25.2	Material		
25.3	Watt-second capacity	Ws	
25.4	Maximum voltage applied to the field winding	V	

Item No.	Parameter	Units	Contractor's Data
25.5	Life time		
26	Excitation system operation in condenser mode	Yes/ No	
27	**Dynamic Braking System**		
27.1	Make/Type		
27.2	Machine Speed at which the dynamic braking is applied	rpm	
28	**Automatic Synchronizer**		
28.1	Type/manufacturer	-	
28.2	Power supply voltage	VDC	
28.3	Power consumption	W	
28.4	Other technical details	-	
28.5	Type/manufacturer	-	
19	**Human Machine Interface (HMI)**		
19.1	Type/manufacturer		
19.2	Applicable standards		
19.3	Number of units	nos.	
19.4	Power requirement	W	
19.5	Supply voltage	V	
19.6	Over all dimensions	mm	
19.7	Screen dimensions	mm	
19.8	Maximum resolution	pixel	

2.6.2 Informative Data

Sl. No	Item	Unit	Technical Particulars
1	**Panels**		
1.1	Panel Designations		
1.2	Make and country of manufacture		
1.3	Weight of each panel section	kg	
1.4	Dimensions of each panel section (Width x Depth x Height)	mm	
1.5	Clearance required around panel	mm	
1.6	General arrangement drawing attached of		
1.7	Individual panel section Overall arrangement of complete panels showing floor space		Yes/No Yes/No
1.8	Changeover facility for power supply provided	Auto / Manual	
2	**General**		

Sl. No	Item	Unit	Technical Particulars
2.1	Special tools & devices for maintenance included. (Attach list)		Yes/No
2.2	Spares		
i)	List of recommended spares for normal maintenance for a period of 5 years furnished (Attach List)		Yes/No
2.3	Following Drawings / Literature submitted :		
i)	Component's list of each panel		Yes/No
ii)	Typical Block / Circuit diagrams of control interlock schemes		Yes/No
2.4	Tests		
i)	Type test certificates for all the components furnished		Yes/No
2.5	Deviations		
i)	All the deviations from the specifications submitted separately. Compliance will be taken for granted if the deviation is not specifically mentioned.		Yes/No
3	**Auxiliary / Interface Relay**		
3.1	Make		
3.2	Type designations		
3.3	Contacts, Hand Reset / Self reset		
3.4	No. of pairs of contacts		
i)	a) Make contacts b) Break contacts		
3.5	Burden of Relay	VA	
3.6	Contact Rating:		
	a) Continuous current b) Voltages c) Making Current & duration d) Breaking current : • Resistive • Inductive, 0.3 P.F • Inductive, L/R=10msec / 40 msec	A V V/SEC A A,AC/DC A,AC/DC	
4	**Timers**		
4.1	Make		
4.2	Type designation		

Sl. No	Item	Unit	Technical Particulars
4.3	Range of time delay		
i)	a) On energisation b) On de-generation	msec msec	
4.4	Accuracy class as per IS		
4.5	Contact Rating :		
i)	a) Continuous current b) Voltages c) Making Current & duration d) Breaking current : • Resistive • Inductive,0.3P.F • Inductive, L/R=10msec/40msec	A V V/SEC A A,AC/DC A,AC/DC	
4.6	No. of pairs of contacts		
i)	a) Make contact b) Break contact		
5	**Control switch**		
5.1	Make & Front Dimensions		
5.2	Type of switch (Stay put / Spring return / Spring return with sequence / discrepancy)		
5.3	Contact Rating		
i)	a) Continuous current b) Voltages c) Making Current & duration d) Breaking current : • Resistive • Inductive 0.3 P.F • Inductive, L/R = 10msec / 40 msec	A V V/SEC A A,AC/DC A,AC/DC	
6	**Push Button**		
6.1	Make		
6.2	Actuator type :		
6.3	i.Momentary / Maintained ii.Shrouded to prevent inadvertent operation		Yes/No Yes/No
6.4	Whether integral engraved inscription plates provided		Yes/No
6.5	Type and No. of NO / NC contacts		
6.6	Contact Rating		
	a) Continuous current b) Voltages c) Making Current & duration d) Breaking current :	A V V/SEC	

Sl. No	Item	Unit	Technical Particulars
	• Resistive • Inductive, 0.3 P.F • Inductive, L/R = 10msec / 40 msec.	A A,AC/DC A,AC/DC	
6.7	Elec. life expectancy based on 300 switching operation cycles/ hour		
7	**Illuminated Push-Button Switches**		
7.1	Make & Front dimensions		
7.2	Actuator type :		
i)	Momentary / Maintained / Selfholding		
7.3	Switching action by actuation of Frontplate / button / knob		
7.4	Legend plate & illumination coloured screens provided		
7.5	i) Lamp type ii) Wattage & Voltage iii)Series resistor provided		
7.6	Material of housing containing illumination portion and switch contacts		
7.7	Type and No. of NO / NC contacts		
7.8	Contact Rating		
i)	Continuous current	A	
ii)	Voltages	V	
iii)	Making Current & duration	V/SEC	
iv)	Breaking current : a) Resistive b) Inductive, 0.3 P.F c) Inductive, L/R = 10msec/ 40 msec.	 A A,AC/DC A,AC/DC	
7.9	Elec. life expectancy based on 300 switching operation cycles per hour		
8	**Indicating Lamps**		
8.1	Type		
8.2	Ratings		
8.3	i) Voltage ii) Wattage	V W	
8.4	Series resistors are provided		
8.5	Series resistor	Ohms Watts	
8.6	Life of lamp in burning hours	Nos.	
9	**Annunciators**		
9.1	Make		
9.2	Dimensions of each window (L x W x H)	mm	

Sl. No	Item	Unit	Technical Particulars
9.3	No. of lamps per window	No.	
9.4	Lamps -	V W	
9.5	Is the sequence of operation as per specification		Yes/No
9.6	Initiating contact requirements		
	i) Making current ii) Impulse duration	A msec	
10	**Indicating Meters**		
10.1	Make		
10.2	Type of movement		
10.3	Type designation		
10.4	CT / VT Sec. current / Volt	A,V	
10.5	Burden :		
	i) Current coil ii) Voltage coil	VA VA	
10.6	Details of shunt, if any		
10.7	i) Rated current ii) Rated voltage drop	A V	
10.8	Accuracy class & standard		
10.9	Total deflection angle	Deg	
10.10	Total scale length	mm	
10.11	Suitable for specified reference operating conditions		Yes/No

2.6.3 Recommended Additional Spare Parts

List hereunder the spare parts which are recommended by the Contractor for purchase in addition to the mandatory spare parts as per Chapter-6 of Volume IV, Section 7. The purchase of any or all of the recommended spare parts will be at the option of KHPL. The prices for recommended additional spare parts for five (5) years shall be quoted separately in the format provided in the Price Schedule (Section F).

Item	Description	Make/Type	Quantity
1			
2			
3			
4			

* Use additional sheets if required

2.6.4 Information to be supplied together with the Bid

At least the information listed hereunder shall be given by the Bidder. The Bidder may submit additional documents /descriptions to describe special technical features of offered equipment / system:

i) Technical offer
ii) Dully filled Datasheet B
iii) Type test certificate of all major items.

iv) General Arrangement drawings of Control relay and panel
v) Vendor list for various components, fittings and accessories.
vi) Catalogues of relays and major items.
vii) Transportation details

2.6.5 Lists of Tools & Instruments

List of tools and instruments in accordance to the clause 6.25 of PTS Chapter-6 under Section-7 of Volume-4 shall be listed below in additional to the list provided by the employer.

Sl. No	Item/Description	Quantity offered
1.	Assembly & erection tools	
2	Testing & Commissioning tools	
3	Testing and Commissioning instruments & devices	
4	Special tools & devices needed for routine maintenance purposes	

2.6.6 Similar Installations (in last 20 years) by the Contactor

Sl. No	Description	Name of owner/utility	Quantity supplied	Year of supply/ commissioning

2.7 Isolated Phase Bus Duct (IPBD)

2.7.1 Guaranteed Technical Particulars

Item No.	Parameter	Units	Contractor's Data
1	**Bus Duct**		
1.1	Manufacturer/place of manufacturer		
1.2	Type/designation		
1.3	Applicable standards		
1.4	Rated voltage	kV	
1.5	Highest system voltage Um	kV	
1.6	Rated frequency	HZ	
1.7	Rated continuous currents		
i)	Main bus	A	
ii)	Delta bus	A	
iii)	Tap off bus	A	
1.8	Degree of protection	IP	
1.9	Type of cooling arrangement	-	
1.10	Pressure, if applicable	mbar	
1.11	Maximum temperature rise at rated continuous current (all connections)		
i)	Conductor	^{0}C	
ii)	Enclosure	^{o}C	
1.12	Thermal short time withstand current, 1s (for all connections)		
i)	Main bus	kA_{rms}	
ii)	Delta bus	kA_{rms}	
iii)	Tap off bus	kA_{rms}	
1.13	Short time dynamic withstand current (for all connections)		
i)	Main bus	kA_{peak}	
ii)	Delta bus	kA_{peak}	
iii)	Tap off bus	kA_{peak}	
1.14	Rated short duration power frequency withstand voltage, 1 min.	kV_{rms}	
1.15	Rated lightning impulse withstand voltage	kV_{peak}	
1.16	Conductor losses at rated continuous current per 3-phase system		
i)	Main bus	W/m	
ii)	Delta connections	W/m	
1.17	Losses in enclosures at rated continuous current per 3-phase system		
i)	Main bus	W/m	
ii)	Delta connections	W/m	
2	**Current Transformers**		
2.1	**General**		
i)	Manufacturer/place of manufacturer		
ii)	Type/designation		
iii)	Applicable standards		
2.2	**Current transformers for split phase protection**		
i)	Rated voltage of equipment	kV	
ii)	Highest voltage for equipment Um	kV	

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Item No.	Parameter	Units	Contractor's Data
iii)	Rated short duration power frequency withstand voltage, 1 min.	kV_{rms}	
iv)	Rated lightning impulse withstand voltage	kV_{peak}	
v)	Rated short-time thermal current, 1s	kA_{rms}	
vi)	Rated dynamic current	kA_{peak}	
vii	Rated primary current	A	
vii	Rated secondary current	A	
ix)	Accuracy class	-	
x)	Burden of core	VA	
2.3	**Neutral-end current transformers**		
i)	Rated voltage of equipment	kV	
ii)	Highest voltage for equipment Um	kV	
iii)	Rated short duration power frequency withstand voltage, 1 min.	kV_{rms}	
iv)	Rated lightning impulse withstand voltage	kV_{peak}	
v)	Rated short-time thermal current, 1s	kA_{rms}	
vi)	Rated dynamic current	kA_{peak}	
vii	Rated primary current	A	
vii	Rated secondary current	A	
ix)	Accuracy class	-	
x)	Burden of core	VA	
2.4	**Line-end current transformers**		
i)	Rated voltage of equipment	kV	
ii)	Highest voltage for equipment Um	kV	
iii)	Rated short duration power frequency withstand voltage, 1 min.	kV_{rms}	
iv)	Rated lightning impulse withstand voltage	kV_{peak}	
v)	Rated short-time thermal current, 1s	kA_{rms}	
vi)	Rated dynamic current	kA_{peak}	
vii	Rated primary current	A	
vii	Rated secondary current	A	
ix)	Accuracy class	-	
x)	Burden of core	VA	
3	**Potential transformers**		
3.1	Manufacturer/place of manufacturer		
3.2	Type/designation		
3.3	Applicable standards		
3.4	Rated voltage of equipment	kV	
3.5	Highest voltage for equipment Um	kV	
3.6	Rated short duration power frequency withstand voltage, 1 min.	kV_{rms}	
3.7	Rated lightning impulse withstand voltage	kV_{peak}	
3.8	Rated transformation ratio		
i)	For protection	kV/V	
ii)	For measuring	kV/V	
iii)	For AVR	kV/V	
3.9	Accuracy class/rated burden		
i)	For protection	-/VA	
ii)	For measuring	-/VA	

Item No.	Parameter	Units	Contractor's Data
iii)	For AVR	-/VA	
4	**Surge arresters**		
4.1	Manufacturer/place of manufacturer		
4.2	Type/designation		
4.3	Applicable standards		
4.4	Rated voltage (Ur)	kV	
4.5	Maximum continuous operating voltage (Uc)	kV	
4.6	Nominal discharge current (8/20 µs)	kA	
4.7	Pressure relief rated current	kA_{rms}	
4.8	Line discharge class	-	
5	**Surge protection capacitors**		
5.1	Manufacturer/place of manufacturer		
5.2	Type/designation		
5.3	Applicable standards		
5.4	Rated voltage (Ur)	kV	
5.5	Maximum continuous operating voltage (Uc)	kV	
5.6	Rated Current	A	
5.7	Pressure relief rated current	kA_{rms}	
5.8	Capacitance	Micro F	
6	**Dynamic braking cubicle**		
6.1	Manufacturer/place of manufacturer		
6.2	Type/designation		
6.3	Applicable standards		
6.4	Transformer		
i)	Continuous rating	kVA	
ii)	Voltage ratio		
iii)	Frequency	Hz	
iv)	No. Of phases		
6.5	Isolator		
i)	Manufacturer		
ii)	Type		
iii)	Rating		
6.6	Insulation Level		
6.7	Degree of Protection		
7	**Neutral grounding cubicle**		
7.1	Manufacturer/place of manufacturer		
7.2	Type/designation		
7.3	Applicable standards		
7.4	Transformer		
i)	Rated continuous power	kVA	
ii)	Rated voltages (no-load) of HV winding/ LV winding	kV	
7.5	Grounding resistor		
i)	Resistance	Ohm	
ii)	Rated voltage	V	

2.7.2 Informative Data

Sl No	Items	Unit	Technical Particulars
1	**Bus Duct**		

Sl No	Items	Unit	Technical Particulars
1.1	Manufacturer		
1.2	Application/designation		
1.3	Applicable standard		
1.4	Type of cooling (Natural/Forced air)		
1.5	Continuous current rating of bus duct under site ambient conditions		
1.6	(a) Forced cooled	Amps	
1.7	(b) Natural cooled	Amps	
1.8	Period for which bus duct can remain on full load from time of failure of cooling system		
1.9	Inductive reactance per phase at 20 deg.C at 50 Hz	Ohm/m	
1.10	Capacitive reactance per phase at 20deg.C at 50 Hz	Ohm/m	
1.11	Minimum phase to phase clearance	mm	
1.12	Minimum phase to earth clearance	mm	
1.13	Weight (three phase) including all accessories	kg/m	
1.14	Standard section length	m	
1.15	Degree of protection		
1.16	Finish		
1.17	(a) Exterior		
1.18	(b) Interior		
1.19	Bidder's bus duct layout drawing no.(for reference)		
1.2	Bus Conductor		
i)	Materials and grade		
ii)	Shape and dimensions		
iii)	Cross sectional area	Sq.mm	
iv)	Method of joining adjacent sections		
v)	Resistance per phase at 20 deg.C	Ohm/m	
1.21	Bus Enclosure		
i)	Material and grade		
ii)	Inner diameter and thickness	mm	
iii)	Cross sectional area	Sq.mm	
iv)	Method of joining adjacent sections		
v)	Resistance per phase at 20 deg.C	Ohm/m	
vi)	Details of Sun Shield		
a)	Material and grade		
b)	Thickness	mm	
c)	Angle of coverage		
d)	Paint shade		
e)	Gap between enclosure & sun shield		
1.22	**Losses**		
i)	Power loss in the isolated phase bus duct at full load		
a)	Middle phase	kW/m	
b)	Each outer phase	kW/m	
c)	Total	kW/m	
ii)	Power loss in bus conductor when carrying rated current	kW/3 ph. Metre run*	
iii)	Power loss in bus enclosure when carrying rated current	kW/3 ph. Metre run*	

Sl No	Items	Unit	Technical Particulars
	*For Delta it is single phase		
iv)	Total power consumption of forced cooling equipment (if any)	kW	
v)	Total power loss = (1.4.2 + 1.4.3) x (Length of bus duct) + 1.4.4	kW	
1.23	Disconnecting/ Shorting Links		
i)	Material and grade		
ii)	Current carrying capacity	Amps	
iii)	Clearances when bolted links are removed	mm	
iv)	Phase to earth clearance (minimum) when shorting links are erected	mm	
1,24	Bolted Flexible Joint for Connection at Equipment End (Data to be furnished for each type/rating of joint)		
i)	Material and grade		
ii)	No. of such braids per joint (per phase)		
iii)	Effective cross sectional area	Sq.mm	
iv)	Current carrying capacity	Amps	
v)	Whether the mating surfaces are silver plated	Yes/No	
1.25	Bellows		
i)	Material and grade		
ii)	Maximum permissible expansion	mm	
1.26	Gaskets		
i)	Material and grade of gaskets used for inspection covers		
1.27	Insulators		
i)	Manufacturer		
ii)	Type		
iii)	Applicable standard		
iv)	Cantilever strength		
a)	Upright	kgm	
b)	Underhung	kgm	
v)	Weight of each insulator	kg	
vi)	Distance between support insulators along the run of bus	metre	
vii)	Number of insulators at each support location (for each conductor (for each rating of bus duct) rating of busduct)	Nos	
1.28	Seal-off Bushings		
i)	Type(s)		
ii)	Applicable standard		
iii)	Material – Porcelain/Epoxy		
iv)	Weight of each bushing	kg	
1.29	Current Transformers (Data to be furnished for each type/rating)		
i)	Application		
ii)	Manufacturer		
iii)	Type		
iv)	Quantity		
2	**Voltage Transformer Cubicles**		
2.1	Voltage transformer (data to be furnished for each type/rating)		

Sl No	Items	Unit	Technical Particulars
i)	Manufacturer		
ii)	Type		
iii)	Quantity		
2.2	Lightning Arrester		
i)	Manufacturer		
ii)	Type (attach descriptive pamphlet)		
iii)	Applicable standard		
iv)	Energy capability	kJ/kV	
v)	Front of wave protective level	kV (Peak)	
vi)	Switching surge protective level at – ka	kV (Peak)	
2.3	Capacitor		
i)	Manufacturer		
ii)	Type (attach descriptive pamphlet)		
iii)	Applicable standard		
2.4	General		
i)	Terminal on earthing bus suitable for (state conductor size)		
3	**Bus Duct supporting structures**		
3.1	Weight of complete steel structures	Tonnes	
4	**Forced Cooling**		
4.1	Type of forced air-cooling system		
4.2	Type of heat exchanger and materials used		
4.3	Temperature rise of cooling water	Deg.C	
4.4	Maximum allowable pressure of cooling water	MMWC	
4.5	Minimum required pressure of cooling water	MMWC	
4.6	Quantity of cooling water required for each heat exchanger	l/min	
4.7	No. of heat exchangers		
4.8	Number of blowers		
5	**Pressurization Equipment**		
5.1	Pressurization equipment suitable for inlet pressure	kg/sq.cm	
5.2	Pressure maintained inside the bus duct	kg/sq.cm	
5.3	Scavenging rate	l/hr	
5.4	Guaranteed leakage rate (through bus ducts)	l/hr	
5.5	Type of Drier		Heater Type / Heater-less Type
6	**Hot Air Blowing Equipment**		
6.1	Motor rating - Voltage	V	
i)	Phases	No.	
ii)	Power	kW	
6.2	Blower Capacity	Cu.m/hr	
i)	Head	MWC	
6.3	Outlet air temperature	Deg.C	
6.4	Thermostat range	Deg.C	
6.5	Drying time for entire installation	Hrs	
7	**Current carrying conductors of bus ducts**		
7.1	Material		

Sl No	Items	Unit	Technical Particulars
i)	Main bus	-	
ii)	Delta bus		
iii)	Tap off bus		
7.2	Cross section and section designation		
i)	Main bus	mm^2	
ii)	Delta bus	mm^2	
iii)	Tap off bus	mm^2	
7.3	Effective resistance of conductor, per phase, at temperature	°C	
i)	Main bus	ohm/m	
ii)	Delta connection	ohm/m	
7.4	Capacitance per phase		
i)	Main bus	F/m	
ii)	Delta connection	F/m	
7.5	Maximum distance between conductor support points		
i)	Main bus	mm	
ii)	Delta connections	mm	
iii)	Tap connections	mm	
7.6	Number of insulators per conductors support point	pcs	
7.7	Insulator material		
8	**Enclosures**		
8.1	Material		
i)	Main bus		
ii)	Delta bus		
iii)	Tap off bus		
8.2	External diameter / Internal diameter		
i)	Main bus	mm	
ii)	Delta bus	mm	
iii)	Tap off bus	mm	
8.3	Centre to centre distance between adjacent phases		
i)	Main bus	mm	
ii)	Delta bus	mm	
iii)	Tap off bus	mm	
8.4	Maximum distance between expansion joints		
i)	Main bus	mm	
ii)	Delta connections	mm	
iii)	Tap connections	mm	
9	**Weight/dimensions**		
9.1	Weight of assembled bus duct per phase		
i)	Main bus	Kg/m	
ii)	Delta bus	Kg/m	
iii)	Tap off bus	Kg/m	
9.2	Maximum unit length of bus duct as prepared for shipment or required during field assembly		
i)	Main bus	mm	
ii)	Delta bus	mm	
9.3	Length of the bus duct per unit from Generator to GSU Transformer excluding delta & tap connections	mm	

Sl No	Items	Unit	Technical Particulars
9.4	Dimensions of complete 3-single phase PT and surge protection cubicle (L x W x H)	mm x mm x mm	
9.5	Dimensions of the neutral grounding cubicle (L x W x H)	mm x mm x mm	
9.6	Dynamic Braking Cubicle	mm x mm x mm	

2.7.3 Recommended Additional Spare Parts

List hereunder the spare parts which are recommended by the Contractor for purchase in addition to the mandatory spare parts as per Chapter-7 of Volume IV, Section 7. The purchase of any or all of the recommended spare parts will be at the option of KHPL. The prices for recommended additional spare parts for five (5) years shall be quoted separately in the format provided in the Price Schedule (Section F).

Item	Description	Make/Type	Quantity
1			
2			
3			
4			

* Use additional sheets if required

2.7.4 Information to be supplied together with the Bid

At least the information listed hereunder shall be given by the Bidder. The Bidder may submit additional documents /descriptions to describe special technical features of offered equipment / system:

i) Technical offer

ii) Dully filled Datasheet B

iii) Type test certificate of similar type of comparable rating.

iv) IPB Layout along with General Arrangement drawings

v) Vendor list for various components, fittings and accessories.

vi) Catalogues for Major items

vii) Transportation details

2.7.5 Lists of Tools & Instruments

List of tools and instruments shall be listed below in additional to the list provided by the employer.

Sl. No	Item/Description	Quantity offered
1	Assembly & erection tools	
2	Testing & Commissioning tools	
3	Testing and Commissioning instruments & devices	
4	Special tools & devices needed for routine maintenance purposes	

2.7.6 Similar Installations (in last 20 years) by the Contactor

Sl. No	Description	Name of owner/utility	Quantity supplied	Year of supply/ commissioning

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2.8 Generator Transformer

2.8.1 Guaranteed Technical Particulars (GT)

SL. No	Descriptions	Unit	To be filled by bidder
1	**Application/Designation**		
1.1	Quantity		
1.2	Installation	Indoor / Outdoor	
1.3	Type	Auto / 2-Wdg / 3-Wdg / Other	
1.4	Three Phase / Single Phase Unit		
1.5	Rating of each Winding	MVA	
1.6	Type of Cooling		
1.7	ONAN / ONAF / OFAF rating		
2	**Ratings**		
2.1	No load voltage		
2.2	LV Winding (primary)	kV	
2.3	HV Winding (secondary)	kV	
2.4	Frequency	Hz	
2.5	Rating for each type of cooling i) ONAN ii) ONAF		
2.6	Percentage impedance	%	
3	**Core**		
3.1	Over fluxing		
4	**Winding connections**		
4.1	Winding Connection (Vector Group)		
4.2	Application / Direction of Power Flow		
5	**System Data**		
5.1	System Voltage		
i)	HV – Nominal / Highest LV – Nominal / Highest	kV / kV kV / kV	
5.2	Fault Level		
i)	LV system (primary)	kA	
ii)	HV system (secondary)	kA	
5.3	System Neutral Earthing:		
	i) Effectively ii) Resonant iii) Non-effectively iv) Isolated	LV (primary) HV (secondary)	

SL. No	Descriptions	Unit	To be filled by bidder
6	**Winding Insulation**		
	i) Uniformly insulated	LV (primary)	
	ii) Non-uniformly insulated	HV (secondary)	
7	**Transformer Neutral**		
i)	Type of earthing		
	(a) Directly	LV (Primary)	
	(b) Non-effectively (c) Isolated	HV (Secondary)	
8	**Winding Insulation Test Voltages**		
8.1	Lightning Impulse voltage withstand +ve/-ve (1.2 / 50μs Wave)		
a)	LV / HV	kV (Peak)	
8.2	Switching Impulse voltage withstand +ve/-ve (250 / 2500μs Wave) for HV	kV(Peak)	
a)	Power frequency voltage withstand		
8.3	LV and HV (primary and secondary)	kV (rms)	
9	**Temperature Rise**		
9.1	Ambient temperature		
9.2	Maximum ambient air		
9.3	Maximum daily average air		
9.4	Maximum yearly average air		
9.5	Cooling water (Maximum)		
9.6	Temperature rise of top oil by thermometer	ºC	
9.7	Maximum temperature rise of windings by resistance	ºC	
10	**Tapping**		
10.1	Tapping on windings		
10.2	Whether on load / off-circuit		
10.3	Tapping range	%	
10.4	Tapping step	%	
10.5	Category of voltage variation (Clauses 3.2, 3.3, 3.4 of IS:2026 Part IV)		
10.6	Capacity	Full / Reduced	
11	**On Load Tap Changer (OLTC)**		

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SL. No	Descriptions		Unit	To be filled by bidder
11.1	Control		Manual / Automatic & Local / Remote	
11.2	Control cubicle		By Vendor / Purchaser	
11.3	Voltage class of OLTC		kV	
11.4	Current rating of OLTC		A	
12	**Terminal Bushings**			
12.1	Particulats	LV Line End (Primary)	HV Line End (Secondary) or (Secondary and tertiary)	HV Neutral end (Secondary)
a)	Rated Voltage class – kV			
b)	Rated current class – A			
c)	Impulse(1.2/ 50 µ sec. Wave withstand) – kV(Peak)			
d)	One minute power frequency withstand (Dry & Wet) kV(rms)			
e)	Minimum clearance in air - mm (ph-ph/ph-gnd)			
f)	Minimum creepage distance in (Total) - mm			
g)	Protected creepage distance – mm			
h)	Voltage tap for use with potential device – Reqd. / Not Reqd.			

13	**Bushing Current Transformer (BCT)**						
13.1	Application	BCT Core No.	B C T Particulars				
			CT Ratio	Class	Knee Point Voltage (V_K) V	Secondary Resistance (Rct) Ohms	Burden (VA)
	a) HV line side for restricted earth fault protectio	1					

SL. No	Descriptions		Unit	To be filled by bidder
	n (star side)			
b)	For winding temperature measurement (star side)	2		
c)	HV neutral side for restricted earth fault protection (star side)	1		
d)	HV neutral side for standby e/f protection (star side)	2		
14	**Terminal Connections**			
14.1	Terminal connections – A/B/C (See Notes on Sh.8)			
i)	LV Wdg (primary) Line end			
ii)	HV Wdg (secondary) Line end			
iii)	HV Wdg (secondary) Neutral end			
14.2	Earthing Conductor			
i)	Material			
ii)	Size			
15	**Miscellaneous**			
15.1	Impulse test			
i)	Full wave		Required / Not Required	
ii)	Chopped wave		Required / Not Required	

SL. No	Descriptions	Unit	To be filled by bidder
15.2	Heat run test	Required / Not Required	
15.3	Any other special test		
15.4	Buchholz Relay	Required / Not required	
15.5	Winding temperature indicator and Oil Temperature indicator		
i)	Local	Required / Not required	
ii)	Remote	Required / Not Required	
15.6	Oil level gauge		
i)	Type	Magnetic / Prismatic	
ii)	Dial size		
15.7	Colour shade of final painting	Shade Number	
15.8	Bolted joint near base of tank	Required / Not Required	
15.9	Skids	Required / Not Required	
15.10	Wheel		
i)	Plain / Flanged		
ii)	Unidirectional / Bi-directional		
iii)	Additional wheels for stability required	Yes / No	
15.11	Vacuum withstand capability		
i)	Main tank with bushings, fittings and accessories		
ii)	Radiators		
15.12	Transformer to be transported:		
i)	Filled with oil		
ii)	Without oil with inert gas, gas cylinder, reducer connection, pressure gauge		

SL. No	Descriptions	Unit	To be filled by bidder
16	Transformer losses: i) No load losses at rated voltage on principal tapping & at rated frequency ii) Load loss at rated current at principal tapping at 75 deg C iii) Auxiliary losses		

2.8.2 Guaranteed Technical Particulars (ICT)

Sl. No	General	Unit	To Be Filled By Bidder
1	**Application/Designation**		
1.1	Quantity		
1.2	Installation	Indoor / Outdoor	
1.3	Type	Auto / 2-Wdg / 3-Wdg / Other	
1.4	Three Phase / Single Phase Unit		
1.5	Rating of each Winding	MVA	
1.6	Type of Cooling		
1.7	ONAN / ONAF / OFAF rating		
2	**Ratings**		
2.1	No load voltage		
2.2	LV Winding (primary)	kV	
2.3	HV Winding (secondary)	kV	
2.4	Frequency	Hz	
2.5	Rating for each type of cooling i) ONAN ii) ONAF		
2.6	Percentage impedance	%	
3	**Core**		
3.1	Over fluxing		
4	**Winding Connections**		
4.1	Winding Connection (Vector Group)		
4.2	Application / Direction of Power Flow		
5	**System Data**		

Sl. No	General	Unit	To Be Filled By Bidder
5.1	System Voltage		
i)	HV – Nominal / Highest LV – Nominal / Highest	kV / kV kV / kV	
5.2	Fault Level		
i)	LV system (primary)	kA	
ii)	HV system (secondary)	kA	
5.3	System Neutral Earthing:		
	i) Effectively ii) Resonant iii) Non-effectively iv) Isolated	LV (primary)	
		HV (secondary)	
6	**Winding Insulation**		
	i) Uniformly insulated	LV (primary)	
	ii) Non-uniformly insulated	HV (secondary)	
7	**Transformer Neutral**		
7.1	Type of earthing		
	i) Directly ii) Non-effectively iii) Isolated	LV (Primary)	
		HV (Secondary)	
8	**Winding Insulation Test Voltages**		
8.1	Lightning Impulse voltage withstand +ve/-ve (1.2 / 50µs Wave)		
i)	LV / HV	kV (Peak)	
8.2	Switching Impulse voltage withstand +ve/-ve (250 / 2500µs Wave) for HV	kV(Peak)	
i)	Power frequency voltage withstand		
8.3	LV and HV (primary and secondary)	kV (rms)	
9	**Temperature Rise**		
9.1	Ambient temperature		
9.2	Maximum ambient air		
9.3	Maximum daily average air		
9.4	Maximum yearly average air		
9.5	Cooling water (Maximum)		

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Sl. No	General	Unit	To Be Filled By Bidder
9.6	Temperature rise of top oil by thermometer	ºC	
9.7	Maximum temperature rise of windings by resistance	ºC	
10	**Tapping**		
10.1	Tapping on windings		
10.2	Whether on load / off-circuit		
10.3	Tapping range	%	
10.4	Tapping step	%	
10.5	Category of voltage variation (Clauses 3.2, 3.3, 3.4 of IS:2026 Part IV)		
10.6	Capacity	Full / Reduced	
11	**On Load Tap Changer (OLTC)**		
11.1	Control	Manual / Automatic & Local / Remote	
11.2	Control cubicle	By Vendor / Purchaser	
11.3	Voltage class of OLTC	kV	
11.4	Current rating of OLTC	A	
12	**Terminal Bushings**		

12.1	Particulats	LV Line End (Primary)	HV Line End (Secondary) or (Secondary and tertiary)	HV Neutral end Secondary)
i)	Rated Voltage class – kV			
ii)	Rated current class – A			
iii)	Impulse(1.2/ 50 µ sec. Wave withstand) – kV(Peak)			
iv)	One minute power frequency withstand (Dry & Wet) kV(rms)			
v)	Minimum clearance in air - mm (ph-ph/ph-gnd)			

Sl. No	General		Unit	To Be Filled By Bidder
vi)	Minimum creepage distance in (Total) - mm			
vii)	Protected creepage distance – mm			
viii	Voltage tap for use with potential device – Reqd. / Not Reqd.			

13	BUSHING CURRENT TRANSFORMER (BCT)					
Application	BCT Core No.	B C T Particulars				
		CT Ratio	Class	Knee Point Voltage (V_K) V	Secondary Resistance (Rct) Ohms	Burden (VA)
HV line side for restricted earth fault protection (star side)	1					
For winding temperature measurement (star side)	2					
HV neutral side for restricted earth fault protection (star side)	1					
HV neutral side for standby e/f protection (star side)	2					

14	TERMINAL CONNECTIONS		
14.1	Terminal connections – A/B/C (See Notes on Sh.8)		
i)	LV Wdg (primary) Line end		
ii)	HV Wdg (secondary) Line end		
iii)	HV Wdg (secondary) Neutral end		
14.2	Earthing Conductor		
i)	Material		
ii)	Size		

Sl. No	General	Unit	To Be Filled By Bidder
15	**MISCELLANEOUS**		
15.1	Impulse test		
i)	Full wave	Required / Not Required	
ii)	Chopped wave	Required / Not Required	
15.2	Heat run test	Required / Not Required	
15.3	Any other special test		
15.4	Buchholz Relay	Required / Not required	
15.5	Winding temperature indicator and Oil Temperature indicator		
i)	Local	Required / Not required	
ii)	Remote	Required / Not Required	
15.6	Oil level gauge		
i)	Type	Magnetic / Prismatic	
ii)	Dial size		
15.7	Colour shade of final painting	Shade Number	
15.8	Bolted joint near base of tank	Required / Not Required	
15.9	Skids	Required / Not Required	
15.10	Wheel		
i)	Plain / Flanged		
ii)	Unidirectional / Bi-directional		
iii)	Additional wheels for stability required	Yes / No	
15.11	Vacuum withstand capability		

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Sl. No	General	Unit	To Be Filled By Bidder
i)	Main tank with bushings, fittings and accessories		
ii)	Radiators		
15.12	Transformer to be transported:	a	
i)	Filled with oil		
ii)	Without oil with inert gas, gas cylinder, reducer connection, pressure gauge		
16	Transformer losses: i) No load losses at rated voltage on principal tapping & at rated frequency ii) Load loss at rated current at principal tapping at 75 deg C iii) Auxiliary losses		

2.8.3 Guaranteed Technical Particulars (Shunt Reactor)

Sl. No.	Item	Unit	To Be Filled By Bidder
1	Reactor application (Line/Neutral)		
2	Installation (Indoor/Outdoor)		
3	Applicable Standards		
4	No. of phases		ONE / THREE
5	Rated voltage & frequency	kV, Hz	
6	Rating (3 phase/1 phase)	kVAR	
7	Rated continuous current	Amps	
8	Measured impedance per phase at rated voltage	Ohms	
9	Rated percentage impedance	%	
10	Zero sequence impedance	Ohms	
11	Linearity of voltage	P.U.Volt	
12	Max. Crest Value of Third Harmonic Content in Phase Current	% of Fundamental	
13	Tolerance in impedance	%	
14	Permissible current unbalance among different phases at maximum system voltage	%	
15	Insulation (full or graded)		
16	Highest system voltages for which reactor windings are suitable	kV	
17	INSULATION WITHSTAND		
17.1	Impulse (1.2/50□ sec WAVE)	kVp	
17.2	Switching surge	kVp	

Sl. No.	Item	Unit	To Be Filled By Bidder
	(250/2500□ sec WAVE)		
17.3	Power frequency test voltage to earth for star point of winding		
i)	Directly earthed neutral	kVrms	
ii)	Neutral earthed through neutral reactor	kVrms	
18	Rated short time current and Specified duration	kA	
19	Winding connections		
20	TERMINAL BUSHINGS		
20.1	Voltage Rating	kV	
20.2	Applicable Standards		
20.3	Total Creepage Distance	mm	
20.4	Impulse Withstand	kVp	
20.5	C.T. Particulars (Ratio, Burden, Accuracy)		
20.6	Terminal connectors supplied as required		□ Yes □ No
21	Type of Cooling		
22	Temperature rise for which the Reactor is designed:		
23	Oil by thermometer	^{0}C	
24	Winding by resistance	^{0}C	
25	Weight of core and winding assembly	kg	
26	Total quantity of oil	Ltrs	
27	Total weight of oil	kg	
28	Total weight of reactor	kg	
29	Losses	kW	

2.8.4 Recommended Additional Spare Parts

List hereunder the spare parts which are recommended by the Contractor for purchase in addition to the mandatory spare parts as per Chapter-8 of Volume IV, Section 7. The purchase of any or all of the recommended spare parts will be at the option of KHPL. The prices for recommended additional spare parts for five (5) years shall be quoted separately in the format provided in the Price Schedule (Section F).

Item	Description	Make/Type	Quantity
1			
2			
3			
4			

* Use additional sheets if required

2.8.5 Information to be supplied together with the Bid

At least the information listed hereunder shall be given by the Bidder. The Bidder may submit additional documents /descriptions to describe special technical features of offered equipment / system:

i) Technical offer
ii) Dully filled Datasheet B
iii) Type test certificate.
iv) General Arrangement drawing
v) Catalogues
vi) Vendor list
vii) Transportation details

2.8.6 Lists of Tools & Instruments

List of tools and instruments shall be listed below in additional to the list provided by the employer.

Sl. No	Item/Description	Quantity offered
1	Assembly & erection tools	
2	Testing & Commissioning tools	
3	Testing and Commissioning instruments & devices	
4	Special tools & devices needed for routine maintenance purposes	

2.8.7 Similar Installations (in last 20 years) by the Contactor

Sl. No	Description	Name of owner/utility	Quantity supplied	Year of supply/ commissioning

2.9 Gas Insulated Switchgear

2.9.1 Guaranteed Technical Particulars

Sl. No.	Description	Unit	To Be Filled By Bidder
1	**Genera**		
1.11	Drawings		
	i) Gas Section Diagram		
	ii) Single Line Diagram		
1.12	Compliance With Technical Specifications		
1.13	List Of Deviations		
1.14	Installation	Indoor/Outdoor	
1.15	Bay Width	Mm	
1.16	Bay Height And Depth	mm	
1.17	Bay Weight	T	
1.18	Thickness Of The Sheet Metal Forming The Housing	mm	
1.19	Internal Fault Locator Type	-	
2	**Circuit Breaker**		
2.1	Applicable Standard	-	
2.2	i) Basic Impulse Level	kV_{peak}	
	ii) Phase To Phase, Phase To Earth		
	iii) Across Open Switching Device		
2.3	i) Switching Impulse Level (For CBS ii) > 300 kV)	kV_{peak}	
2.4	Rated Operating Duty Cycle	-	
2.5	Rated Short Circuit Making Capability	kA	
2.6	Rated Interrupting Capability (Symmetrical) & Duration	kA /Sec	
2.7	Rated Interrupting Capability (Asymmetrical) & Duration	kA /ms	
2.8	Rated Percentage Dc		
	Component & X/R Ratio		
2.9	Rated Small Inductive Breaking Current	A	
2.1	First Pole To Clear Factor	-	
2.11	i) Rated Transient Recovery		
	ii) Voltage For		
	iii) Terminal Faults	kVPeak kV_{Peak}	
	iv) Short Line Faults		
2.12	Rated Characteristics For Short Line Faults:		
	i) Surge Impedance		
	ii) Amplitude Constant (KA)	W	

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Sl. No.	Description	Unit	To Be Filled By Bidder
iii	Rate Of Rise Of Recovery Voltage (RRRV)	kV/Ms	
iv	Critical Line Length	L	
2.13	Total Operation Time		
	i) Closing	msec	
	ii) Tripping	msec	
2.14	Operating Voltage Range		
	i) Closing Coil	VDC	
	ii) Tripping Coil		
2.15	Operating Power		
i)	Closing Coil	Watts	
ii)	Tripping Coil	Watts	
2.16	Rated Line Charging Breaking Current	A	
2.17	Rated Cable Charging Breaking Current	A	
2.18	Rated Small Inductive Current Breaking Capability	A	
2.19	Out Of Phase Breaking Current	kA	
2.2	Rated Reactive Current		
i)	Breaking Capability (If Applicable)	A	
2.21	Rated Capacitive Current Breaking Capability	A	
2.22	Rated Single Capacitor Bank		
i)	Switching Current Breaking	A	
ii)	Capability (If Applicable)	A	
2.23	Voltage Withstand Vs Time Graph		
2.24	Operating Mechanism Type		
2.25	Operating Pressure Minimum		
i)	Maximum	Kg/cm^2	
2.26	Drive Motor Rating	Ph,V	
2.27	Enclosure Protection Class	IP	
2.28	Hydraulic Driven Pump A) Rating		
i)	Type		
2.29	Emergency Operation When Aux. Supply Is Not Available	-	
2.30	Time Difference Between First & Last Pole, For Opening & Closing	msec	
2.31	Tests Facility At The Works A) Routine		
ii)	Type	-	
2.32	Breaker Contact Resistance	MW	
3	**Disconnecting Switches**		

Sl. No.	Description	Unit	To Be Filled By Bidder
3.1	Type	-	
3.2	Ratings		
i)	Rated Voltage Of Motor	V	
ii)	Type & Number Of Motors	-	
iii)	Range Of Operating Voltage	V kV	
iv)	Short Time Making Capability		
v)	For Each Of The Grounding	A	
vi)	Switches)		
vii)	Rated Bus Transfer Switching		
viii)	Current (Double Bus Only)		
3.3	Number Of Auxiliary Contacts	-	
i)	Normally Open (No)	-	
ii)	Normally Closed (Nc)	-	
iii)	Spare		
3.4	Rated Maximum Closing Time	Sec.S	
3.5	Rated Maximum Opening Time	Sec.S	
3.6	Provision Of Inspection Windows		
3.7	Drive Mechanism Details	-	
3.8	i) Test Facility For Routine & Type		
	ii) Tests At The Works	-	
4	**Grounding Switches**		
4.1	Type		
4.2	Ratings		
i	Rated Voltage Of Motor	V	
ii	Type & Number Of Motors	-	
iii	Range Of Operating Voltage	V, KA	
iv	Short Time Making Capability		
v	For Each Of The Grounding	A	
vi	Switches)		
vii	Rated Small Inductive	A	
viii	Current Breaking		
ix	Rated Small Capacitive		
x	Current Breaking		
4.3	Number Of Auxiliary Contacts		
	Normally Open (No)	-	
	Normally Closed (NC)	-	
	Spare	-	
4.4	Maximum Closing Time	Sec.S	
4.5	Maximum Opening Time	Sec.S	
4.6	i) Pole Discrepancy Protection	-	
	ii) For Independent Motor		
	iii) Operated Grounding Switches		
4.7	Provision Of Inspection Windows	-	

Sl. No.	Description	Unit	To Be Filled By Bidder
4.8	Drive Mechanism Details	-	
4.9	Test Facility For Routine & Type	-	
	Tests At The Works		
5	**Instrument Transformers**		
5.1	**Voltage Transformer**		
i)	Applicable Standard	-	
ii)	Type		
iii	Ratings:		
a)	Voltage Ratio	V	
b)	Class Of Accuracy	-	
c)	Extended Tap Voltage	VA	
d)	Burden	-	
e)	Revenue Metering Core Accuracy	-	
i)	a) Rating And Connection Details		
	b) Whether As Per Tender Single		
	c) Line Diagram		
ii)	a) Tests Reports:		
	b) Routine		
	c) Type Tests		
5.2	**Current Transformers**		
i)	Type And Designation Number	-	
ii)	Type Of Insulation And Class	-	
iii	Rated Primary Current	A	
iv	Rated Secondary Current	A	
v)	Continuous Thermal Current		
vi	Rating Factor		
a)	Multi Ratio CTS	KA KA	
b)	Single Ratio CTS		
vi	Rated Short Time Withstand Current:	KA RMS	
a)	Thermal Withstand Current	KAp	
b)	(Ith)	(2.5 Ith)	
c)	Rated Peak Dynamic Withstand Current		
vi	Rated Short Time Thermal Current/ Duration	A/Sec.	
ix	Rated Primary Short Circuit Current, Temperature Rise	KA, °C	
x)	Number Of Current Transformers		
a)	Number Of Metering Cores Per Ct		
b)	Number Of Relaying Cores Per Ct		
xi	Core No.		

Sl. No.	Description	Unit	To Be Filled By Bidder
a)	Purpose (Relaying Or Metering)		
b)	Type Of Protection (Back Up/		
	• Differential/Distance		
	• Protection Etc.)		
c)	Current Ratio At Specified Tap		
d)	Accuracy Class		
e)	Burden (VA)/Resistive Burden -Rb		
f)	Secondary Winding Resistance		
xi	At 20ºc, RCT (Ohms)		
a)	For Class TPS CTS per IEC		
	• Rated Symmetrical Short Circuit		
	• Current At 20ºc		
	• Rated Rct		
	• Dimensioning Parameter		
	• Excitation Limiting Secondary Voltage.		
	• Accuracy Limiting Secondary		
	• Excitation Current		
	• Secondary Excitation Current,		
	• At Half Excitation Limiting		
	• Secondary Voltage		
b)	For Class C Or K CTS per IEEE /		
	• Class P CTS per IEC		
	• Magnetizing Current		
	• Knee Point Voltage		
	• Secondary Limiting E.M.F		
c)	Class Tps Or Class Px Cts- Turns Compensation Considered If Any		
6	**GIS Surge Arrester**		
6.1	GIS Surge Arresters		
6.2	Rated Arrester Voltage	kV RMS	
6.3	One Minute Power Frequency Withstand Voltage	kV RMS	
6.4	Discharge Class Of Arrester	kJ/kV	
6.5	Maximum Continuous Operating Voltage (Mcov)	kV RMS	
6.6	Maximum Energy Absorbtion Capability		
i)	Kj/Kv Of Arrester Rating - Kj/Kv Of Mcov		
6.7	Nominal Discharge Current (8/20ms Wave).	Ka Peak	
6.8	High Current Impulse (4/10ms Wave)	Ka Peak	
6.9	Long Duration Wave Withstand		
i)	Capability		
ii	Current	A	

Sl. No.	Description	Unit	To Be Filled By Bidder
iii	Duration	msecs	
6.10	Temporary Overvoltge		
i)	Capability	kV RMS	
ii)	1 Second		
iii	10 Seconds		
6.11	Pressure Relief Capability		
	High Current Short Duration	KA RMS	
	Low Current Long Duration	A	
6.12	Weight Of A Surge / Lightning Arrestor	Kg	
6.13	Discharge Counter Per Surge / Lightning Arrestor	Yes Or No	
7	**SF_6 Bus Ducts**		
7.1	i) Enclosure Material	-	
	ii) Bushing Material	-	
	iii) Provision Of Expansion Bellows For Indoor/Outdoor		
	iv) Transit.		
	v) Provision Of Bus Duct Supports		
7.2	Rating	-	
i)	Voltage Rating	V	
ii)	Continuous Current @ 40˚c	A/˚c KA/˚C	
iii	Short Time Current &		
iv	Temperature	kV	
v)	Impulse Withstand Voltage		
8	**GIS Enclosure**		
8.1	i) Enclosure Material	-	
	ii) Bushing Material	-	
	iii) Provision Of Expansion Bellows For Indoor/Outdoor	-	
	iv) Transit.		
	v) Maximum Metal-Metal Gis Enclosure Voltage Difference	$E'_{to}max$	
8.2	Details Of Pressure Relief Devices Including Setting	-	
8.3	i) Performance Parameters	-	
	ii) Potential Rise During Fault	Volts Watts	
	iii) Power Loss/Phase		
	iv) Temperature Rise Under Normal And Short Circuit Conditions.	^{o}c	
8.4	SF6 Pressures		
i)	a) Filling Pressure (At 20^0c) A. Cb Section	Bar	
	b) Other Section		
ii	a) Min. Service Pressure Range	Bar	
	b) (At 20^0c)		
iii	a) Rupture Diaphragm Bursting	Bar	

Sl. No.	Description	Unit	To Be Filled By Bidder
	b) Pressure		
iv	a) Design Pressure Of The	Bar	
	b) Adaptor Housing		
v)	a) Bursting Pressure Of Adaptor	Bar	
	b) Housing		
8.5	a) Temperature Rise Of		
	b) Enclosures At Rated Current	^{O}C	
	c) And Normal Operation		
9	**SF_6 to Air Terminal Bushings**		
9.1	Make	-	
9.2	Type Of Bushing Housing		
9.3	Rating	-	
	i) Voltage Rating	V	
	ii) Continuous Current Rating	A KA RMS kV Peak	
	iii) Short Time Current Rating		
	iv) Impulse Withstand		
9.4	i) Design Parameters		
	ii) Operating Pressure	Kg/M^2	
	iii) Test Pressure	Kg/M^2	
	iv) Bursting Pressure	Kg/M^2	
	v) Cantilever Strength		
	a) Static	Kg/M	
	b) Dynamic	Kg/M	
9.5	Creepage Distance	mm	
9.6	SF6 To Oil Cable Termination Requirement	-	
10	**SF6 Gas**		
10.1	Name Of Manufacturer	-	
10.2	Electrical Properties	-	
10.3	Transportation Details	-	
10.4	Acceptable Moisture Content (By Weight)	-	
10.5	i) Guaranteed Moisture Content A. On Commissioning		
	ii) After 12 Months	-	
11	**Local Control Cabinet (LCC)**		
11.1	Type Of LCC Control/Protection	-	
11.2	Industry Standard For	-	
i)	LCC	-	
ii)	Annunciator System		
11.3	Annunciator Type And Designation Number		
11.4	i) Number Of Annunciator		
	ii) Windows Size Of Annunciator Windows		
11.5	Letter Size Of Annunciator Window	mm	

Sl. No.	Description	Unit	To Be Filled By Bidder
11.6	i) Drawing Attachments Of Wiring/		
	ii) Interconnection Block Diagrams		
11.7	Alarm Logic Unit Response Time	msecs.	
11.8	Annunciator First Out Feature Provided?		
11.9	Ac Backup Supply For Annunciator	VAC	
11.1	DC Power Supply Voltage Range	VDC	
11.11	DC Power Supply For Annunciator	VDC	
11.12	Dimensions Of Cabinet	mm	
12	**Support Structures**		
12.1	Applicable Standards	-	
12.2	i) Design Criteria A) Static Load		
	ii) Dynamic Load (S)	Kg	
	iii) Corrosion Factor	Kg	
	iv) Safety Factor	-	
	v) Seismic Acceleration Factor	-	
12.3	Hot dip galvanising specification	-	
12.4	Tests To Be Carried Out At Work	-	
13	**Partial Discharge Monitoring System**	Optional	
13.1	P.D. Monitoring System Type		
13.2	Sensors	No.S	
13.3	Couplers	No.S	
13.4	On Line Monitoring Panel	Type	
13.5	Hand Held Monitor		
13.6	Data Storage Capacity	Mb	
13.7	Resolution Time	Millisecs	
13.8	Provision Of Data Printer		
14	**Special Tools**		
14.1	Special Tools Required For SF_6		
14.2	Gas Filling, Removing,		
14.3	Maintaining And Testing		
14.4	SF_6 Gas Leakage Detector:		
i)	Manufacturer		
ii)	Type	-	
iii)	Sensitivity	-	
14.2	Mobile SF_6 Gas Treatment Plant:	Kg	
i)	Storage Capacity	Kg	
ii)	Filtration/Purification Rate	Kg	
14.3	SF_6 Gas Maintenance Cart:		
i)	Storage Capacity		
ii)	Vacuum Pump Rating		
14.4	Portable Moisture Analyser		
i)	Manufacturer		

Sl. No.	Description	Unit	To Be Filled By Bidder
ii)	Type Designation		
iii)	Range		
iv)	Sensitivity		
v)	Accuracy		
15	General Information		
15.1	Net Weight Of Complete GIS:		
i)	With SF6 Gas	kg	
ii)	Without Sf6 Gas	kg	
15.2	i) Weight Of Support Structure ii) Weight Of Heaviest Shipping Unit iii) Overall Height (Mm) iv) Overall Depth (Mm) v) Overall Width (Mm) vi) Recommended Clearance around GIS vii) Overhead Traveling Crane Capacity	kg mm mm mm mm kg	
15.3	Impact Loading Of Circuit Breaker During Open And Close Operations	kg	
15.4	Maximum Static And Dynamic Operating Loads Of The Gis	kg	
16	Optional &/Or Special Test Requirements If Any		

2.9.2 Recommended Additional Spare Parts

List hereunder the spare parts which are recommended by the Contractor for purchase in addition to the mandatory spare parts as per Chapter-9 of Volume IV, Section 7. The purchase of any or all of the recommended spare parts will be at the option of KHPL. The prices for recommended additional spare parts for five (5) years shall be quoted separately in the format provided in the Price Schedule (Section F).

Item	Description	Make/Type	Quantity
1			
2			
3			
4			

* Use additional sheets if required

2.9.3 Information to be supplied together with the Bid

At least the information listed hereunder shall be given by the Bidder. The Bidder may submit additional documents /descriptions to describe special technical features of offered equipment / system:

i) Technical offer.

ii) Gas SLD

iii) Preliminary GAS layout.

iv) Technical Data sheet of all major items.

v) Type test certificates valid for five years for all equipment/plants/accessories being supplied under this CONTRACT.

2.9.4 Lists of Tools & Instruments

List of tools and instruments in accordance to the clause 9.29 of PTS Chapter-9 under Section-7 of Volume-4 shall be listed below in additional to the list provided by the employer.

Sl. No	Item/Description	Quantity offered
1	Assembly & erection tools	
2	Testing & Commissioning tools	
3	Testing and Commissioning instruments & devices	
4	Special tools & devices needed for routine maintenance purposes	

2.9.5 Similar Installations (in last 20 years) by the Contactor

Sl. No	Description	Name of owner/utility	Quantity supplied	Year of supply/ commissioning

2.10 420 kV and 145 kV XLPE Cables

2.10.1 Guaranteed Technical Particulars

Sl. No.	Item	Unit	Contractor's Data
1	Name of Manufacturer		
2	Address of Manufacturer's Works		
3	Cable code		
4	Standards applicable		
5	**Voltage Grade**		
5.1	i) Rated Voltage (Uo / U) ii) System Voltage (U) iii) Highest System Voltage (Um)	kV	
6	Short circuit withstand capacity of conductor for 1 sec. without exceeding the conductor temperature of 250°C.	kA	
7	Recommended operating temperature		
7.1	i) Continuous ii) Emergency	°C °C	
8	Permissible overload conditions		
8.1	i) Maximum conductor temperature ii) Duration	°C Hrs.	
9	**Conductor**		
9.1	Conductor material		
9.2	Conductor shape		
9.3	Nominal cross-sectional area	sq.mm.	
9.4	Maximum DC resistance at 20 deg C	Ohms per km	
9.5	Maximum AC resistance at 90 deg C	Ohms per km	
9.6	Apprx overall diameter of conductor	mm	
9.7	Maximum dielectric stress at conductor	kV	
10	**Extruded Conductor Screen**		
10.1	Material		
10.2	Thickness of extruded layer	mm	
10.3	Maximum dielectric stress at conductor screen	kV	
11	**Insulation**		
11.1	Material		
11.2	Nominal thickness of insulation	mm	
11.3	Type of curing		
11.4	Does the insulation meet the minimum characteristics specified in tender specification	Yes/No	
11.5	Any special feature which the Bidder would like to highlight		

Sl. No.	Item	Unit	Contractor's Data
12	**Insulation Screen**		
12.1	Material		
12.2	Thickness of extruded screen	mm	
12.3	Resistivity of semi conducting screen	Ohm-mtr	
13	**Synthetic Water Blocking Layer Above Conductor Insulation Shield/Screen**		
13.1	Material		
13.2	Thickness	mm	
13.3	Configuration		
14	**Metal Sheath Provided**	Yes/No	
14.1	Material		
14.2	Configuration		
14.3	Short circuit withstand capacity for 1 sec.	kA	
15	**Synthetic Water Blocking Layer Above Metal Sheath**		
15.1	Material		
15.2	Thickness	mm	
15.3	Configuration		
16	**Metal Screen/ Shield**		
16.1	Material		
16.2	Configuration		
16.3	Total cross-sectional area	sq.mm.	
16.4	Short circuit withstand capacity for 1 sec.	kA	
17	**Synthetic Water Blocking Layer above Metal Screen**		
17.1	Material		
17.2	Thickness	mm	
17.3	Configuration		
18	**Separator Sheath**		
18.1	Material		
18.2	Thickness	mm	
19	**Armor**		
19.1	Material		
19.2	Type		
19.3	Nominal diameter/thickness of wire/strip	mm	
19.4	Short circuit withstand capacity for 1 sec.	kA	
20	**Outer Sheath**		
20.1	Material		
20.2	Nominal thickness	mm	

Sl. No.	Item	Unit	Contractor's Data
20.3	Whether FRLS type	Yes/No	
20.4	i) Temperature index ii) Light transmission index iii) Total acid gas generation iv) Standard to which flammability will be tested		
21	**Conducting Layer Over Outer Sheath**		
21.1	Material		
21.2	Nominal thickness	mm	
22	**Physical Details**		
22.1	Overall diameter of finished cable	mm	
22.2	Diameter of cable over armour	mm	
22.3	Diameter of cable under armour	mm	
22.4	Nominal weight per meter of cable	kg	
22.5	Minimum bending radius for cable installation	mm	
22.6	Length of cables in one drum and tolerance	mtr	
22.7	Weight of cable drum without cable	kg	
22.8	Weight of cable drum with cable	kg	
22.9	Transport dimensions of cable drum (diameter and length)		
22.10	Whether cross sectional sketch of cables furnished	Yes/No	
23	**Current Ratings**		
23.1	Continuous current rating of single cable in air at ambient temperature of 40°C	A	
23.2	Continuous current rating in air at site conditions i) Screen bonded to earth at one end ii) Screen bonded to earth at both ends iii) Screen and sheath/armour cross bonded to earth	 A A A	
23.3	Derating factors for laying i) In trefoil formation in air ii) In trefoil formation in ducts iii) In trefoil formation in ground iv) For different thermal resistivity and ground temperature v) For grouping vi) 2 trefoils with 400 mm spacing		
24	**Sheath Over Voltages**		
24.1	Maximum sheath over voltage at specified fault current and direction for one km route length with one end of cable bonded to earth	kV	
24.2	Whether surge or sheath voltage suppressors recommended by Bidder and provided		

Sl. No.	Item	Unit	Contractor's Data
25	Combined voltage drops due to all factors at rated voltage per km.	%	
26	Total power loss of cable per km of 3 phase circuit when laid direct in ground at rated voltage and frequency	Watts	
27	Type of terminations offered		
28	Type of straight through joint offered		
29	Whether earth link boxes offered	Yes/No	
30	Whether cable pulling eye provided at the unwinding end of the cable drum integral with the sealing end	Yes/No	
31	TESTS		
31.1	Whether type test reports enclosed with bid		
31.2	Whether agreeable to conduct acceptance tests as per tender specification	Yes/No	
31.3	Whether agreeable to conduct special tests as per tender specification	Yes/No	
32	Whether technical deviations furnished in schedule of technical deviations	Yes/No	
33	Details of erection tools and maintenance tools.		
34	Any special data desired to be indicated by Bidder.		

2.10.2 Recommended Additional Spare Parts

List hereunder the spare parts which are recommended by the Contractor for purchase in addition to the mandatory spare parts as per Chapter-10 of Volume IV, Section 7. The purchase of any or all of the recommended spare parts will be at the option of KHPL. The prices for recommended additional spare parts for five (5) years shall be quoted separately in the format provided in the Price Schedule (Section F).

Item	Description	Make/Type	Quantity
1			
2			
3			
4			

* Use additional sheets if required

2.10.3 Information to be supplied together with the Bid

At least the information listed hereunder shall be given by the Bidder. The Bidder may submit additional documents /descriptions to describe special technical features of offered equipment / system:

i) Technical offer
ii) Data sheet for cables
iii) Type and routine test certificates Bill of quantity
iv) Vendor list for various components, fittings and accessories.
v) Catalogues.

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2.10.4 Lists of Tools & Instruments

List of tools and instruments shall be listed below in additional to the list provided by the employer.

Sl. No	Item/Description	Quantity offered
1	Assembly & erection tools	
2	Testing & Commissioning tools	
3	Testing and Commissioning instruments & devices	
4	Special tools & devices needed for routine maintenance purposes	

2.10.5 Similar Installations (in last 20 years) by the Contactor

Sl. No	Description	Name of owner/utility	Quantity supplied	Year of supply/ commissioning

2.11 Pothead Yard

2.11.1 Guaranteed Technical Particulars

Sl. No.	Description	Unit	To Be Filled By Bidder
1	**CVT (For Line Protection & metering)**		
1.1	Name and Address of Manufacture		
1.2	Manufacturer's type designation		
1.3	Standards Applicable		
1.4	Nominal System Voltage Ur (rms)		
1.5	Rated Secondary Voltage (rms)		
i)	Winding No. I		
ii)	Winding No. II		
iii)	Winding No. III		
iv)	Winding No. IV		
1.6	Transformation ratio of Three windings		
1.7	Number of Secondary windings		
1.8	Number of Phases for CVT		
1.9	Rated System frequency		
1.1	Installation		
i)	Type of Mounting		
ii)	Type of Earthing		
iii)	Rated output of each secondary winding		
a)	Winding No. I		
b)	Winding No. II		
c)	Winding No. III		
d)	Winding No. IV		
1.14	Accuracy of each secondary winding		
i)	Winding No. I		
ii)	Winding No. II		
iii)	Winding No. III		
iv)	Winding No. IV		
1.15	Simultaneous burden/ Accuracy Class		
1.16	Rated total thermal burden		
1.17	Highest System Voltage		
1.18	Rated Voltage factor and corresponding rated time		
i)	i) Continuous		
ii)	ii) 30 second		
1.19	Accuracy class of each secondary winding		
i)	Rated output VA Burden		
ii)	Accuracy class		
iii)	Ratio Error		

Sl. No.	Description	Unit	To Be Filled By Bidder
iv)	Phase Error		
2	**CVT (For Line TVM)**		
2.1	Name and Address of Manufacture		
2.2	Manufacturer's type designation		
2.3	Standards Applicable		
2.4	Nominal System Voltage Ur (rms)		
2.5	Rated Secondary Voltage (rms)		
i)	Winding No. I		
ii)	Winding No. II		
2.6	Transformation ratio of Three windings		
2.7	Number of Secondary windings		
2.8	Number of Phases for CVT		
2.9	Rated System frequency		
2.10	Installation		
2.11	Type of Mounting		
2.12	Type of Earthing		
2.13	Rated output of each secondary winding		
i)	Winding No. I		
ii)	Winding No. II		
2.14	Accuracy of each secondary winding		
i)	Winding No. I		
ii)	Winding No. II		
2.15	Simultaneous burden/ Accuracy Class		
2.16	Rated total thermal burden		
2.17	Highest System Voltage		
2.18	Rated Voltage factor and corresponding rated time		
i)	Continuous		
ii)	ii) 30 second		
2.19	Accuracy class of each secondary winding		
i)	Rated output VA Burden		
ii)	Accuracy class		
iii)	Ratio Error		
iv)	Phase Error		
2.20	Storage Vertical/horizontal		
2.21	Type of Bellow		
3	**Current Transformers - 4 Core(For Line Protection & metering)**		
3.1	Type and designation number		

Sl. No.	Description	Unit	To Be Filled By Bidder
3.2	Type of insulation and class		
3.3	Rated primary current		
3.4	Rated secondary current		
3.5	Continuous thermal current		
i)	Rating factor		
a)	Multi Ratio CTS		
b)	Single Ratio CTS		
3.6	Rated short time withstand current:		
i)	Thermal withstand current		
ii)	(Ith)		
iii)	Rated Peak Dynamic Withstand Current		
3.7	Rated short time thermal current/ duration		
3.8	Rated primary short circuit current, temperature rise		
3.9	Number of current transformers		
i)	Number of metering cores per CT		
ii)	Number of relaying cores per CT		
3.10	I. Core no.		
i)	Purpose (relaying or metering)		
ii)	Type of protection (back up)		
a)	Differential/distance		
b)	Protection etc.)		
i)	Current ratio at specified tap		
ii)	Accuracy class		
iii)	Burden (VA)/Resistive Burden -RB		
a)	(OHMS)		
iv)	Secondary Winding Resistance		
v)	AT 20ºC, Rct (OHMS)		
	a) For class TPS CTs PER IEC		
	• Rated symmetrical short circuit		
	• Current at 20ºC		
	• Rated RCT		
	• Dimensioning parameter		
	• Excitation limiting secondary voltage.		
	• Accuracy limiting secondary		
	• Excitation current		
	• Secondary excitation current,		
	• At half excitation limiting		
	• Secondary voltage		

Sl. No.	Description	Unit	To Be Filled By Bidder
	b) For class C OR K CTS PER IEEE		
	• Class P CTS PER IEC		
	• Magnetizing current		
	• Knee point voltage		
	• Secondary limiting E.M.F		
4	**Current transformers -2 Core(For Line TVM)**		
4.1	Type and designation number		
4.2	Type of insulation and class		
4.3	Rated primary current		
4.4	Rated secondary current		
4.5	Continuous thermal current		
i)	Rating factor		
a)	Multi ratio CTS		
b)	Single ratio CTS		
4.6	Rated short time withstand current:		
i)	Thermal withstand current		
ii)	(Ith)		
iii)	Rated peak dynamic withstand current		
4.7	Rated short time thermal current/ duration		
4.8	Rated primary short circuit current, temperature rise		
4.9	Number of current transformers		
i)	Number of metering cores per CT		
ii)	Number of relaying cores per CT		
iii)	Core No.		
a)	Purpose (relaying or metering)		
b)	Type of protection (back up/		
c)	Differential/distance		
d)	Protection etc.)		
e)	Current ratio at specified tap		
f)	Accuracy class		
g)	Burden (va)/resistive burden -rb		
h)	(Ohms)		
i)	Secondary winding resistance		
j)	AT 20ºc, Rct (OHMS)		
iv)	For class TPS CTs PER IEC		
a)	Rated symmetrical short circuit		
b)	CURRENT AT 20ºc		
c)	Rated rct		
d)	Dimensioning parameter		
e)	Excitation limiting secondary voltage.		

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Sl. No.	Description	Unit	To Be Filled By Bidder
f)	Accuracy limiting secondary		
g)	Excitation current		
h)	Secondary excitation current,		
i)	At half excitation limiting		
j)	Secondary voltage		
v)	FOR CLASS C OR K CTS PER IEEE /		
	CLASS P CTS PER IEC		
a)	Magnetizing current		
b)	Knee point voltage		
c)	Secondary limiting E.M.F		
4.10	CLASS TPS OR CLASS PX CTS-turns compensation considered if any		
4.11	Cantilever Strength		
4.12	Maximum deflection at above cantilever load		
4.13	Mounting flange dimensional details		
4.14	Dry arcing distance		
5	**Surge Monitor**		
Counter Operation			
5.1	Make		
5.2	Model		
5.3	Type		
5.4	Sensitivity of Surge Counter		
	(Min. current at which the Counter operates)		
5.5	Nominal Discharge Current		
5.6	Max. Current to be withstood by the Surge Monitor		
5.7	Counter operation		
Operation of Current Meter			
5.8	Safe Leakage Current Indication		
5.9	Indication of deterioration of Surge Arrester		
5.10	Net. Weight(kG)		
6	**Bus Post Insulator**		
6.1	Applicable standards IS:5350 / IEC:60273 / IEC:60168 / IEC:60815		
6.2	Type		
6.3	General Tolerance		
6.4	Colour of Glaze		
6.5	All ferrous parts are to be hot dip galvanized as per IS:2633/lS:4759		
6.6	Pollution level as per IEC:60815		
6.7	Min.Nom.Creepage distance	mm	

Sl. No.	Description	Unit	To Be Filled By Bidder
6.8	Nominal Weight of complete stack (approx)	kg.	
6.9	MECHANICAL VALUES	kNm	
i)	Ultimate Cantilever strength (Upright)		
ii)	Ultimate Torsional strength		
iii)	Ultimate Tensile strength		
iv)	Ultimate Compression strength		
6.10	ELECTRICAL VALUES		
i)	Nominal system voltage	kV(rms)	
ii)	Highest system voltage	kV(rms)	
iii)	One Minute Power frequency withstand voltage (Dry)	kV(rms)	
iv)	One Minute Power frequency withstand voltage (Wet)	kV(rms)	
v)	One Minute Power frequency flashover voltage (Dry)	kV(rms)	
vi)	One Minute Power frequency flashover voltage (Wet)	kV(rms)	
vii)	Lightning impulse withstand voltage (1.2 / 50 p sec. +Ve/—Ve wave)	kV(rms)	
viii)	Lightning impulse flashover voltage (+ve wave)	kV(rms)	
ix)	Switching impulse withstand voltage (Wet)	kVp	
x)	Min. Corona extinction voltage	kV(rms)	
6.11	RADIO INTERFERENCE VOLTAGE DATA		
i)	Test voltage to ground	kV(rms)	
ii)	Max. RIV at 1 MHz	uv.	
7	**LA Standard Confirms**		
7.1	Basic insulation Level		
7.2	Standard Nominal Discharge Current of Protective Device for 8/20 Micro Second Wave Impulse.	-	
7.3	Rated voltage of the Arrester (Protective Device).		
7.4	Maximum Residual Discharge voltage of protective Device for 8/20 micro second impulse Discharge current of		
i)	5,000 Amps		
ii)	10,000 Amps		
7.5	Class of insulation of Line trap as per Table-I of IEC-60353		
7.6	Temperature Rise in Line Trap under rated Continuous current.		
7.7	Visual Corona Extinction voltage		

Sl. No.	Description	Unit	To Be Filled By Bidder
7.8	Radio Interference voltage		
7.9	Type of incoming and outgoing terminals.		
7.10	Visual Corona Extinction voltage for terminal connector		
7.11	Radio Interference voltage in Terminal connectors.		
7.12	Continuous current rating of terminal connector at 50 Deg. C ambient.		
7.13	Short time current rating of terminals connectors		
7.14	Temperature rise in terminal connector under rated continuous current over 50 Deg. C ambient.		
7.15	Type of Mounting		
7.16	Maximum working stress		
7.17	Ultimate Tensile strength		
7.18	Material of main coil		
7.19	Material of Terminal connector		
7.20	Material of Pedestal		
7.21	Material of mounting hardware		
7.22	Net weight (Approx.)		
7.23	Whether Corona Rings are provided		
7.24	Whether Bird Barrier are provided		
7.25	Overall dimensions provided		
i)	Diameter		
ii)	Height		
7.26	Any other feature		
7.27	No. of turns in line trap Main Coil		
7.28	Type of conductor wheather solid or stranded		
7.29	Overall conductor size		
7.30	Creoss sectional area of conductor		
7.31	Type of construction (No. of coils. and whether open type or covered with insulating material).		
7.32	Line trap shall be mechanically strong enough to withstand stress due to maximum wind pressure of 260 kg/Sq.M (As per cl.6.12.1 SEC-PLCC of Tech. specification).		
7.33	Q Factor (at 100 kHz)		
8	**Isolator**		
8.1	GENERAL		
i)	Name of the manufacturer		
ii)	Country of Manufacture		

Sl. No.	Description	Unit	To Be Filled By Bidder
iii)	Manufacturer's type designation		
iv)	Standard applicable for Isolators and earthing switches		
v)	Rated Voltage Ur (kV)		
vi)	Continuous rated Current Under site conditions (A) at 50°C Ambient		
vii)	Rated frequency (Hz)		
viii)	Number of poles		
ix)	Whether all 3 poles are ganged mechanically		
x)	Pole to pole spacing		
xi)	Type of installation		
8.2	GUARANTEED RATINGS		
i)	Rated short time current of Isolator for 1s (kA) and Dynamic current (kAp)		
ii)	Opening & Closing time of Isolator		
iii)	Opening & Closing time of Earth Switch		
iv)	Temperature rise over 50 deg.C ambient temperature Corresponding to maximum continuous current deg.C.		
8.3	Dielectric withstand capacity of completely assembled Isolator / Isolator and Earth Switch		
i)	One minute dry power freq. Withstand test Voltage (kV rms)		
a)	Between live terminals and ground (kVrms)		
b)	Between terminals when Isolator open (kVrms)		
ii)	1.2/50 microseconds impulse withstand test voltage		
a)	Between live terminals and ground (kVp)		
b)	Between terminals when Isolator open (kVp)		
iii)	250/2500 microseconds switching surge withstand test voltage (dry and wet)		
a)	Between live terminals and ground (kVp)		
b)	Between terminals when Isolator open (kVp)		
iv)	Corona Extinction voltage (kVrms)		
v)	Max. Radio interference level at 1.1 Ur Ö3 at 1.0 MHz (micro volts)		

Sl. No.	Description	Unit	To Be Filled By Bidder
vi)	Total creepage distance to ground (mm)		
vii)	Seismic Acceleration		
8.4	OPERATING MECHANISM		
i)	For Main Blades		
a.	Type of Motor Operating/Manually driven mechanism		
b.	Manufacturer's Type designation		
c.	Rated torque of the mechanism		
d.	Type, rating & make of motor		
ii)	For Earth Switches		
a.	Type of Motor Operating/Manually driven mechanism		
b.	Manufacturer's Type designation		
c	Rated torque of the mechanism		
d.	Type, rating & make of motor		
8.5	**Interlocks**		
i)	Whether mechanical/constructional interlock between Isolator & Earth Switch provided		
ii)	Details of Electrical interlock enclosed for		
a)	Isolator		
b)	Earth Switch		
iii)	Arrangement provided to prevent electrical or manual Operation unless interlock conditions are satisfied		
iv)	Whether interlock coil is continuously rated		
v)	Rated DC control voltage		
vi)	Power consumption (W)		
8.6	**Controls**		
i)	Rated DC control voltage (V)		
ii)	Limits of voltage		
iii)	Power consumption of control coils (W)		
9	**Gantry**		
9.1	Beam geometry		
i)	Beam height at the center of column from G.L.	m	
ii)	Column height on left side span of design beam from G.L.	m	
iii)	Column height on right side span of design beam from G.L.	m	
iv)	Beam span from the center of the column	m	

Sl. No.	Description	Unit	To Be Filled By Bidder
v)	Beam elevation height	m	
vi)	Beam plan width	m	
vii)	Distance between column center to first phase	m	
viii)	Distance between first phase to second phase	m	
ix)	Distance between second phase to third phase	m	
x)	Distance between third phase to column center	m	
9.2	Details of main bus side stringing of designed beam		
i)	Name of conductor	-	
ii)	Aluminum strands	No./mm	
iii)	Steel strands	No./mm	
iv)	Cross section area	m^2	
v)	Ultimate tensile strength	Kg.	
vi)	Unit weight	Kg./m	
vii)	Modulus of elasticity	$Kg./m^2$	
viii)	Coefficient of linear expansion	/°C	
ix)	Overall diameter	m	
x)	Conductor span	m	
xi)	No. of sub-conductor / phase	Nos.	
xii)	Spacing between two sub-conductors	m	
xiii)	Conductor deviation angle in elevation	Deg.	
xiv)	Conductor deviation angle in plan	Deg.	
xv)	Diameter of insulator	m	
xvi)	No. of insulator string	Nos.	
xvii)	Length of insulator string	m	
xviii)	Weight of one insulator string + H.W.	Kg.	
xix)	Effective wind area of insulator	%	
xx)	Spacer span	m	
xxi)	No. of Spacers	Nos.	
xxii)	Unit Spacer Weight	Kg.	
9.3	Jumper Details		
i)	Length of jumper conductor	m	
ii)	Diameter of jumper conductor	m	
iii)	Unit weight of jumper conductor	Kg./m	
iv)	No. of sub-conductor / phase	Nos.	
v)	Diameter of pilot insulator	m	

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Sl. No.	Description	Unit	To Be Filled By Bidder
vi)	No. of pilot insulator string	Nos.	
vii)	Length of pilot insulator string	m	
viii)	Weight of one insulator string + H.W.	Kg.	
ix)	Effective wind area of pilot insulator	%	
x)	Weight of man with tools	Kg.	
10	**String Hardware**		
10.1	Anchor Shackle		
10.2	Ball Link		
10.3	Socket Clevis		
10.4	Yoke Plate		
10.5	Cleves Eye		
10.6	Suspension Clamp		
10.7	R-Clip		
10.8	Split Pin		
10.9	Arcing Horn		

2.11.2 Recommended Additional Spare Parts

List hereunder the spare parts which are recommended by the Contractor for purchase in addition to the mandatory spare parts as per Chapter-11 of Volume IV, Section 7. The purchase of any or all of the recommended spare parts will be at the option of KHPL. The prices for recommended additional spare parts for five (5) years shall be quoted separately in the format provided in the Price Schedule (Section F).

Item	Description	Make/Type	Quantity
1			
2			
3			
4			

* Use additional sheets if required

2.11.3 Information to be supplied together with the Bid

At least the information listed hereunder shall be given by the Bidder. The Bidder may submit additional documents /descriptions to describe special technical features of offered equipment / system:

i) Technical offer (including Tentative SLD and Substation layout and protection SLD.

ii) Type test certificate of similar type of comparable rating.

iii) Catalogues/drawings and datasheets for major item.

iv) Bill of Quantities.

v) Transportation details.

2.11.4 Lists of Tools & Instruments

List of tools and instruments shall be listed below in additional to the list provided by the employer.

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Sl. No	Item/Description	Quantity offered
1	Assembly & erection tools	
2	Testing & Commissioning tools	
3	Testing and Commissioning instruments & devices	
4	Special tools & devices needed for routine maintenance purposes	

2.11.5 Similar Installations (in last 20 years) by the Contactor

Sl. No	Description	Name of owner/utility	Quantity supplied	Year of supply/ commissioning



2.12 Cooling Water System

2.12.1 Guaranteed Technical Particulars

Item No.	Parameter	Units	Contractor's Data
1	**Centrifugal (circulating) pump**		
1.1	Manufacturer/place of manufacture	-	
1.2	Type/designation	-	
1.3	Applicable standards	-	
1.4	Number of pumps per unit	nos.	
1.5	Maximum dynamic head with pumps working in parallel	m	
1.6	Unit discharge corresponding to maximum dynamic head	l/min.	
1.7	Maximum shut-off head of pumps	m	
1.8	Pumping capacity at maximum continuous rating (MCR)	lpm	
1.9	Speed of pump	rpm	
1.10	Pump impeller		
i)	Number of impeller per pump		
ii)	Material of impeller		
1.11	Type of motor (Horizontal / vertical)		
1.12	No. of phases, power factor		
1.13	Operating voltage / frequency		
1.14	Rated horse power	H.P.	
1.15	Duty of pumps		
1.16	Insulation class of pump-motors		
1.17	Protection class of pump-motors	IP	
1.18	Motor service factor		
2	**Submersible/bore well Pumps**		
2.1	Manufacturer/place of manufacture	-	
2.2	Type/designation	-	
2.3	Applicable standards	-	
2.4	Number of pumps per unit	nos.	
2.5	Maximum dynamic head with pumps working in parallel	m	
2.6	Unit discharge corresponding to maximum dynamic head	l/min.	
2.7	Maximum shut-off head of pumps	m	
2.8	Pumping capacity at maximum continuous rating (MCR)	lpm	
2.9	Speed of pump	rpm	
2.10	Pump impeller		
i)	Number of impeller per pump		
ii)	Material of impeller		
2.11	Type of motor (Horizontal / vertical)		
2.12	No. of phases, power factor		
2.13	Operating voltage / frequency		
2.14	Rated horse power	H.P.	
2.15	Duty of pumps		
2.16	Insulation class of pump-motors		
2.17	Protection class of pump-motors	IP	
2.18	Motor service factor		
3	**Cyclone separators**		

Item No.	Parameter	Units	Contractor's Data
3.1	Make/manufacturer		
3.2	Type/designation		
3.3	Applicable standards		
3.4	Total numbers		
3.5	Cleaning effectiveness of system, particles filtered down to		
4	**Automatic/manual self-flushing strainer/filter (to be given separately for each type)**		
4.1	Make/manufacturer		
4.2	Type/ designation		
4.3	Total number	Nos.	
4.4	Design head	m	
4.5	Water flow rate at design head and at maximum continuous rating	lpm	
4.6	Minimum design pressure for filters	kg/cm^2	
4.7	Maximum pressure drop across automatic self-cleaning filter	kg/cm^2	
4.8	Cleaning effectiveness, particulate matter down to	microns	
4.9	Filter cleaning effectiveness for the above	%	
4.10	Whether wedge wire filter element provided	Yes/No	
4.11	Whether candle type filter element provided	Yes/No	
4.12	Motor details (for motorized strainer)		
i)	Rated voltage/frequency	V/Hz	
ii)	Power consumption	kW	
iii)	IP protection	IP	
iv)	Insulation class		
v)	Service factor		
5	**Heat exchanger**		
5.1	Make/manufacturer		
5.2	Type/ designation		
5.3	Applicable standards		
5.4	Total number	nos.	
5.5	Primary system water temperature		
i)	Inlet maximum	°C	
ii)	Outlet	°C	
5.6	Secondary system water temperature		
i)	Inlet maximum	°C	
ii)	Outlet	°C	
6	**Cooling water pipe lines**		
6.1	Minimum design pressure for pipe and pipe fittings	bars	
6.2	Maximum fluid velocity in pipe	m/s	
7	**Temperature sensors & gauges/pressure switches & gauges/transducers/flow meter switches & relays, limit switches, RTDs, etc.**		
7.1	Make		
7.2	Input voltage		
7.3	Output		
7.4	No. Of contact		
7.5	Indicating range		

Item No.	Parameter	Units	Contractor's Data
7.6	Auxiliary contact rating		
7.7	Minimum design pressure for instrumentation	kg/cm 2	
8	**Control Panel**		
8.1	Make/manufacturer		
8.2	Type/ designation		
8.3	Applicable standards		
8.4	Type, make and rating of starters/ contactors		
8.5	Details of safety devices		
8.6	Type & wattage of lamps		
8.7	Type and size of Ammeter & Voltmeter, if provided		
8.8	Size of Panel	LxWx H	
8.9	Compatibility with SCADA (SCADA on IEC 61850/IEC 60870-5-104 communication protocol)	Yes/N o	
8.10	Type of mounting (Floor/wall)		
8.11	Paint shade (Exterior/Interior)		
9	**Material/standard/class/grade/type for**		
9.1	Cooling water pumps		
i)	Pump casing		
ii)	Pump and motor shaft		
iii)	Pump impeller		
9.2	Automatic/manual self-cleaning strainer/ filter		
i)	Filter element/ candle		
ii)	Housing		
9.3	Heat exchanger		
i)	Plates of plate heat exchanger		
ii)	Gaskets of heat exchanger		
10	**Maximum cooling water temperature rise**	°C	

2.12.2 Informative Data

Item No.	Parameter	Units	Contractor's Data	Remarks
1	**General**			
1.1	Whether pump characteristics are furnished	Yes/No		
1.2	Major dimensions of the cooling water pumps with motors	mm x mm x mm		
1.3	W eight of complete pump/motor	kg		
2	**Automatic/manual self-cleaning strainer/ filter**			
2.1	Dimensions of the filter (LXW XH)	mm x mm x mm		
3	**Expansion tank for cooling**			
3.1	Total numbers	nos.		
3.2	Capacity per tank	l		

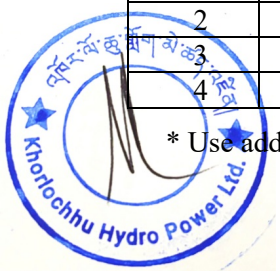
Item No.	Parameter	Units	Contractor's Data	Remarks
3.3	Make-up water requirement	l/h		
3.4	Dimensions of tank (LXW XH)	mm x mmx mm		
4	**Heat exchanger**			
4.1	Manufacturer			
4.2	Heat transfer capacity	kW		
4.3	Total nos. Of plate required	nos.		
4.4	Dimension of plate	mm x mmx mm		
4.5	Minimum gap between the plates	mm		
4.6	Dimensions of complete assembly	mm x mmx mm		
5	**Valves (to be given separately for each type)**			
5.1	Make/manufacturer			
5.2	Type/ designation			
5.3	Applicable standards			
5.4	Total number	nos.		
5.5	Size (NB)	mm		
5.6	Minimum design pressure for valves	bar		
5.7	Motor details (for motorized valves)			
i)	Rated voltage/frequency	V/Hz		
ii)	Power consumption	kW		
iii)	IP protection	IP		
iv)	Insulation class			
v)	Service factor			
6	**Material/ standard/ class/ grade**			
6.1	**Piping**			
i)	Embedded piping			
ii)	Exposed piping			
iii)	Pipe insulation / lagging			
6.2	**Valves**			
i)	DN 50 and below			
ii)	Above DN 50			

2.12.3 Recommended Additional Spare Parts

List hereunder the spare parts which are recommended by the Contractor for purchase in addition to the mandatory spare parts as per Chapter-12 of Volume IV, Section 7. The purchase of any or all of the recommended spare parts will be at the option of KHPL. The prices for recommended additional spare parts for five (5) years shall be quoted separately in the format provided in the Price Schedule (Volume 3).

Item	Description	Make/Type	Quantity
1			
2			
3			
4			

* Use additional sheets if required



2.12.4 Information to be supplied together with the Bid

At least the information listed hereunder shall be given by the Bidder. The Bidder may submit additional documents /descriptions to describe special technical features of offered equipment / system:

i) Description of proposed cooling water system with broad schematic arrangement indicating clearly the suction points, arrangement of the system components, layout of the headers and sub headers and intent of the system in brief.

ii) Pamphlet of proposed pumps giving at least the following information:

a. Pump flow characteristic.

b. Description of mechanical sealing arrangement etc.

c. Cross-section of pump with motor.

d. Description of starter and starter panel.

iii) Pamphlets containing technical particulars and selection criteria of cyclone separators.

iv) Pamphlets containing technical particulars and selection criteria for multimedia filters/ strainers and automatic filters.

v) Pamphlets containing technical particulars of flow meters, level detectors, pressure switch, pressure transducers etc.

2.12.5 Lists of Tools & Instruments

List of tools and instruments in accordance to the clause 12.14 of PTS Chapter-12 under Section-7 of Volume-4 shall be listed below in additional to the list provided by the employer.

Sl. No	Item/Description	Quantity offered
1	Assembly & erection tools	
2	Testing & Commissioning tools	
3	Testing and Commissioning instruments & devices	
4	Special tools & devices needed for routine maintenance purposes	

2.12.6 Similar Installations (in last 20 years) by the Contactor

Sl. No	Description	Name of owner/utility	Quantity supplied	Year of supply/ commissioning

2.13 Compressed Air System

2.13.1 Guaranteed Technical Particulars

Item No.	Parameter	Units	Contractor's Data
1	**LP Compressors**		
1.1	Manufacturer/place of manufacturer		
1.2	Type/ designation		
1.3	Applicable standard		
1.4	Number of units	Nos.	
1.5	Nominal discharge pressure	Kg/cm^2	
1.6	Unit discharge rate	m^3/h	
1.7	Free air Deliver (FAD)	m^3/h	
1.8	Max. pressure for operation of safety device	Kg/cm^2	
1.9	Duty of the compressor motor		
1.10	Insulation and protection class of the motor	IP	
1.11	Motor service factor		
1.12	Rated power of compressor motor	KW	
1.13	Supply Voltage and frequency	V, Hz	
1.14	Method of starting compressor motor		
1.15	Number of stages	Nos.	
1.16	Number and type of after coolers	Nos./type	
1.17	Type of safety device		
1.18	Specific power requirement	kW H/m^3	
1.19	Maximum noise level at any place 1.0m from the compressors	dB(A)	
1.20	Overall operating efficiency	%	
2	**LP air receivers**		
2.1	Manufacturer/place of manufacturer		
2.2	Type/ designation		
2.3	Applicable standard		
2.4	Number of receivers	Nos.	
2.5	Volume per receiver	m^3	
2.6	Design pressure	Kg/cm^2	
2.7	Working pressure	Kg/cm^2	
3	**LP air dryer**		
3.1	Manufacturer/place of manufacturer		
3.2	Type/ designation		
3.3	Applicable standard		
3.4	Number of dryers		
3.5	Unit discharge rate	m^3/h	
3.6	Percentage of moisture removal	%	
3.7	Working temperature	^0C	
3.8	Design pressure	Kg/cm^2	
3.9	Working pressure	Kg/cm^2	
3.10	Filtration Elements		

2.13.2 Informative Data

Item No.	Parameter	Units	Contractor's Data
1	**LP Compressor Unit**		
1.1	Weight of complete compressor	Kg	

Item No.	Parameter	Units	Contractor's Data
1.2	Overall dimension (Length x width x height)	mm x mm x mm	
2	**LP air receivers**		
2.1	material		
3	**LP air dryer**		
3.1	material		
4	**Pipes**		
4.1	Material and sizes		
4.2	Thickness		

2.13.3 Recommended Additional Spare Parts

List hereunder the spare parts which are recommended by the Contractor for purchase in addition to the mandatory spare parts as per Chapter-13 of Volume IV, Section 7. The purchase of any or all of the recommended spare parts will be at the option of KHPL. The prices for recommended additional spare parts for five (5) years shall be quoted separately in the format provided in the Price Schedule (Volume 3).

Item	Description	Make/Type	Quantity
1			
2			
3			
4			

- Use additional sheets if required

2.13.4 Information to be supplied together with the Bid

At least the information listed hereunder shall be given by the Bidder. The Bidder may submit additional documents /descriptions to describe special technical features of offered equipment / system:

i. Pamphlets containing technical particulars of compressor with all accessories.

ii. Pamphlets containing technical particulars of air dryer and LP air receivers etc.

iii. Details with regards to major dimension of the compressors, compressor motors, receivers, air dryers, etc.

2.13.5 Lists of Tools & Instruments

List of tools and instruments in accordance to the clause 13.14 of PTS Chapter-13 under Section-7 of Volume-4 shall be listed below in additional to the list provided by the employer.

Sl. No	Item/Description	Quantity offered
1	Assembly & erection tools	
2	Testing & Commissioning tools	
3	Testing and Commissioning instruments & devices	
4	Special tools & devices needed for routine maintenance purposes	



2.13.6 Similar Installations (in last 20 years) by the Contactor

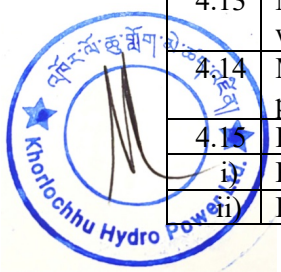
Sl. No	Description	Name of owner/utility	Quantity supplied	Year of supply/ commissioning

2.14 Drainage and Dewatering System

2.14.1 Guaranteed Technical Particulars

Item No.	Parameter	Units	Contractor's Data	Remarks
1	**Powerhouse drainage pumps**			
1.1	Manufacturer/place of manufacture			
1.2	Type/ designation			
1.3	Applicable standard			
1.4	Number of pumps	Nos.		
1.5	Unit discharge at rated head	Lpm		
1.6	Duty of pump-motors			
1.7	Insulation class of pump-motors			
1.8	Protection class of pump-motors	IP		
1.9	Motor service factor			
1.10	Speed of pump	rpm		
1.11	Maximum water submergence pressure	bar		
1.12	Motor rated power	kW		
1.13	Maximum dynamic head with pumps working in isolation	m		
1.14	Maximum dynamic head with all pumps working in parallel	m		
1.15	Efficiency of			
i)	Pump	%		
ii)	Pump motor assembly	%		
iii)	Pump motor	%		
1.16	Maximum shut-off head of pumps	m		
1.17	Motor speed	rpm		
2	**Oil- water sump pumps in transformer cavern**			
2.1	Manufacturer/place of manufacture			
2.2	Applicable standard			
2.3	Type/ designation			
2.4	Number of pumps	Nos.		
2.5	Unit discharge at rated head	Lpm		
2.6	Duty of pump-motors			
2.7	Insulation class of pump-motors			
2.8	Protection class of pump-motors	IP		
2.9	Motor service factor			
2.10	Speed of pump	rpm		
2.11	Maximum water submergence pressure	bar		
2.12	Motor rated power	kW		
2.13	Maximum dynamic head with pumps working in isolation	m		
2.14	Maximum dynamic head with all pumps working in parallel	m		

Item No.	Parameter	Units	Contractor's Data	Remarks
2.15	Efficiency of			
i)	Pump	%		
ii)	Pump motor assembly	%		
iii)	Pump motor	%		
2.16	Maximum shut-off head of pumps	m		
2.17	Motor speed	rpm		
3	**Submersible pump for drainage of cooling water pit**			
3.1	Manufacturer/place of manufacturer			
3.2	Type/ designation			
3.3	Applicable standard			
3.4	Number of pumps	Nos.		
3.5	Unit discharge at rated head	Lpm		
3.6	Duty of pump-motors			
3.7	Insulation class of pump-motors			
3.8	Protection class of pump-motors	IP		
3.9	Motor service factor			
3.10	Speed of pump	rpm		
3.11	Maximum water submergence pressure	bar		
3.12	Motor rated power	kW		
3.13	Maximum dynamic head with pumps working in isolation	m		
3.14	Maximum dynamic head with all pumps working in parallel	m		
3.15	Efficiency of			
i)	Pump	%		
ii)	Pump motor assembly	%		
iii)	Pump motor	%		
3.16	Maximum shut-off head of pumps	m		
3.17	Motor speed	rpm		
4	**Submersible pump for Drainage of Pressure shaft bottom adit**			
4.1	Manufacturer/place of manufacture			
4.2	Type/ designation			
4.3	Applicable standard			
4.4	Number of pumps	Nos.		
4.5	Unit discharge at rated head	Lpm		
4.6	Duty of pump-motors			
4.7	Insulation class of pump-motors			
4.8	Protection class of pump-motors	IP		
4.9	Motor service factor			
4.10	Speed of pump	rpm		
4.11	Maximum water submergence pressure	bar		
4.12	Motor rated power	kW		
4.13	Maximum dynamic head with pumps working in isolation	m		
4.14	Maximum dynamic head with all pumps working in parallel	m		
4.15	Efficiency of			
i)	Pump	%		
ii)	Pump motor assembly	%		



Item No.	Parameter	Units	Contractor's Data	Remarks
iii)	Pump motor	%		
4.16	Maximum shut-off head of pumps	m		
4.17	Motor speed	rpm		
5	**Level sensing devices**			
5.1	Manufacturer/place of manufacture			
5.2	Type/ designation			
5.3	Applicable standard			
6	**Material/ Standard/Class/Grade/ Type for**			
6.1	Powerhouse drainage, flood protection of Powerhouse			
i)	Pump casing			
ii)	Pump motor shaft			
iii)	Pump impeller			
iv)	Chain, guide rail, guide support			
6.2	Transformer cavern drainage			
i)	Pump casing			
ii)	Pump motor shaft			
iii)	Pump impeller			
iv)	Chain, guide rail, guide support			
6.3	Submersible pump for drainage of cooling water pit			
i)	Pump casing			
ii)	Pump motor shaft			
iii)	Pump impeller			
iv)	Chain, guide rail, guide support			
6.4	Submersible pump for Drainage of Pressure shaft bottom adit			
i)	Pump casing			
ii)	Pump motor shaft			
iii)	Pump impeller			
iv)	Chain, guide rail, guide support			
6.5	Piping			
i)	Embedded piping			
ii)	Exposed piping			
iii)	Pipe insulation / lagging			
iv)	Chain, guide rail, guide support			

2.14.2 Information Data

Item No.	Parameter	Units	Contractor's Data
1	**Powerhouse drainage pumps**		
1.1	Whether pump characteristics value furnished	Yes/No	
1.2	Major dimensions of the pumps (LXW XH)	mm x mm x mm	
2	**Oil- water sump pumps in transformer cavern**		
2.1	Whether pump characteristics value furnished	Yes/No	
2.2	Major dimensions of the pumps (LXW XH)	mm x mm x mm	
3	**Submersible pump for Drainage of cooling water pit**		

Item No.	Parameter	Units	Contractor's Data
3.1	Whether pump characteristics value furnished	Yes/No	
3.2	Major dimensions of the pumps (LXW XH)	mm x mm x mm	
4	**Submersible pump for Drainage of pressure shaft bottom audit**		
4.1	Whether pump characteristics value furnished	Yes/No	
4.2	Major dimensions of the pumps (LXW XH)	mm x mm x mm	
5	**General (applicable to all drainage systems)**		
5.1	Kind of measures to prevent water hammer, if any		

2.14.3 Recommended Additional Spare Parts

List hereunder the spare parts which are recommended by the Contractor for purchase in addition to the mandatory spare parts as per Chapter-14 of Volume IV, Section 7. The purchase of any or all of the recommended spare parts will be at the option of KHPL. The prices for recommended additional spare parts for five (5) years shall be quoted separately in the format provided in the Price Schedule (Volume 3).

Item	Description	Make/Type	Quantity
1			
2			
3			
4			

* Use additional sheets if required

2.14.4 Information to be supplied together with the Bid

At least the information listed hereunder shall be given by the Bidder. The Bidder may submit additional documents /descriptions to describe special technical features of offered equipment / system:

i. Pamphlets of the proposed pumps giving at least the following information
   a. Pump flow characteristics
   b. Cross section of pump with motor

ii. Pamphlets of the proposed level sensing devices and level transducer giving the technical particulars and other operational and installation features.

2.14.5 Lists of Tools & Instruments

List of tools and instruments in accordance to the clause 14.14 of PTS Chapter-14 under Section-7 of Volume-4 shall be listed below in additional to the list provided by the employer.

Sl. No	Item/Description	Quantity offered
1	Assembly & erection tools	
2	Testing & Commissioning tools	
3	Testing and Commissioning instruments & devices	
4	Special tools & devices needed for routine maintenance purposes	



2.14.6 Similar Installations (in last 20 years) by the Contactor

Sl. No	Description	Name of owner/utility	Quantity supplied	Year of supply/ commissioning



2.15 DC System

2.15.1 Guaranteed Technical Particulars

Sl. No	Description	Unit	To be filled by bidder
1	**Battery**		
1.1	Manufacturer's Name		
1.2	Standards to which battery is manufactured		
1.3	Rated Capacity At 27ºC		At 10 hour rate
1.4	Expected life of battery	Years	
1.5	Recommended charging rate		
i)	Float charging Voltage / Current	V / A	
ii)	Trickle charging Voltage / Current	V / A	
iii)	Rapid Boost charging Voltage / Current duration	V / A /Hr	
iv)	Normal Boost charging voltage / Current / duration	V / A /Hr	
v)	Equalising charge		
a)	Voltage / current	V / A	
b)	Duration	Hrs	
c)	Interval between successive equalising charges	Days	
d)	Criteria to initiate the same		
1.6	Expected fault level at bus due to battery	kVA	
1.7	Internal resistance of each cell (fully charged)	Ohms	
1.8	Total resistance of battery including resistance of inter-cell connectors	Ohms	
1.9	AH efficiency at rated load	%	
1.10	Watt hour efficiency	%	
1.11	Type of containers		
i)	Type of cell		
ii)	Overall dimensions		
iii)	Each cell L x W x H	mm	
iv)	Weight		
v)	Each cell	kg	
vi)	Complete	kg	
vii)	Whether explosion vents are offered	Yes / No	
1.12	Ventilation requirements		
1.13	Whether there would be any harmful effect on the life of battery if discharged as per load cycle specified above, after being maintained in float charging condition.	Yes / No	
1.14	List of spares / accessories enclosed	Yes / No	
2	**Battery Charger**		
2.1	Manufacturer's Name		
2.2	Type		

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Sl. No	Description	Unit	To be filled by bidder
2.3	Ratings		
2.4	Input voltage	V AC Phase	FLOAT CH. BOOST CH.
2.5	Output voltage	V DC	
i)	Nominal		
ii)	Setting range		
2.6	Rated output	kW	
2.7	Type of AVR / controller		
i)	Voltage regulation with AVR, when supply voltage fluctuation is ±10%, frequency fluctuation is -5% to +3% and load variation is 0% to 100%	%	
ii)	Voltage regulation with manual controller.	%	
iii)	Type of voltage / current control and adjustment provided for boost charger.		
2.8	Guaranteed efficiency		
i)	At 50% load	%	
ii)	At rated load	%	
2.9	Power factor		
i)	At 50% load		
ii)	At rated load		
2.10	Maximum permissible temperature rises over ambient.		
i)	Rectifier transformer	ºC	
ii)	Rectifier cells	ºC	
iii)	Smoothing reactor	ºC	
2.11	Class of insulation		
i)	Rectifier transformer		
ii)	Smoothing reactor		
2.12	Method of cooling		
i)	Rectifier cells		
ii)	Transformer		
2.13	Ripple content at rated load		
i)	With battery	%	
ii)	Without battery	%	
2.14	Rectifier and Blocking Diodes		
i)	Make and Type		
2.15	Silicon controlled Rectifiers (SCR)		
i)	Make and Type		
ii)	RMS current rating	A	
iii)	Peak inverse voltage continuous	V	
2.16	Fault indicating lamps and necessary circuit provided as required	YES/NO	
2.17	Potential free contacts for each fault provided	YES/NO	
2.18	Common alarm contact provided	YES/NO	

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Sl. No	Description	Unit	To be filled by bidder
2.19	Overall dimensions of charger (LxWxH)	mm	
2.20	Degree of Protection		
2.21	Weight	kg	
2.22	List of spares/accessories enclosed	YES/NO	
3	**DC Switchgear**		
3.1	**General Particulars**		
i)	Manufacturers name		
ii)	Modular construction.	Yes/No	
iii)	Fully draw-out /semi-draw-out /fixed	FD/SD/F	
iv)	Dimension of the switchgear L x W x D	mm L W D	
v)	Bus bar continuous rating	A DC	
vi)	Short time rating (1sec)	kA DC	
vii)	Degree of protection provided by the enclosure (as per IS:13947 or equivalent)		
viii)	Earth bus bar size	mm	
3.2	**MCCB / MCB**		
i)	Make & Type		
ii)	Service Voltage	V DC	
iii)	No. of poles and breaks per pole		
iv)	Rated operating duty		
v)	Rated current	A	
vi)	De-rating factor for operation under site conditions		
vii)	Rating breaking current at _____V DC	kA DC	For L/R = _____ms.
viii)	Rated short time current for (1 sec.)	kA DC	
ix)	Rated making current	kA DC	
x)	Number of opening the circuit is capable of performing without inspection, replacement of contacts or other parts at 110% rated breaking current		
xi)	Overload release settings		
xii)	Short circuit release settings and time delay features provided	Yes/No	
xiii)	Under voltage release settings		
3.3	**Bus Bars**		
i)	Material of bus bars		
ii)	Size	mm	
iii)	Type of insulation		
iv)	Whether bus bars have been taped	Yes/No	

Sl. No	Description	Unit	To be filled by bidder
v)	Maximum continuous current rating	A DC	
vi)	Temperature rise over the specified ambient when carrying rated current.	°C	
vii)	Maximum fault withstand current rating (peak)	kA DC	
viii)	Maximum fault withstand current momentary rating (peak)	kA DC	
ix)	Dielectric strength	Volts AD rms	
x)	One min. power frequency withstand voltage.	kV rms	
3.4	**Air Break Switches**		
i)	Make & Type		
ii)	Rated Current	A	
iii)	De-rating factor for use under site ambient conditions		
3.5	**D.C. Contactors**		
i)	Make		
ii)	Rated duty		
iii)	Rated utilisation category		
iv)	Limits of operation a) Supply voltage variation. b) Dropout voltage	 ± % ± %	
3.6	**Fuses**		
i)	Make & Type		
ii)	Rated current	A	
iii)	Category of duty as per IS:9224		
iv)	Rupturing capacity (prospective current)	kA	
v)	Maximum let through current for 1sec	kA	
3.7	**Under Voltage Relay**		
i)	Make & Type		
ii)	Burden	VA	
iii)	Setting range	V	
3.8	**Auxiliary Relays**		
i)	Make & Type		
ii)	Coil burden	VA	
iii)	Operating time	Sec	
iv)	Time delay range (for timer)	Sec	
v)	Resetting features		
vi)	No. of contacts i) Normally open ii) Normally closed		
vii)	Contact rating.	A	
viii)	Whether operation indicator is provided	Yes/No	
3.9	**Control/Selector Switch**		

Sl. No	Description	Unit	To be filled by bidder
i)	Make & Type		
ii)	Spring return or stay put		
iii)	Type of handle		
3.10	**Voltmeter**		
i)	Make & Type		
ii)	Accuracy class		
3.11	**Ammeter**		
i)	Make & Type		
ii)	Accuracy class		
3.12	**Watt Meter**		
i)	Make & Type		
ii)	Accuracy class		
3.13	**Indicating Lamps**		
i)	Make & Type		
3.14	**Push Buttons**		
i)	Make & Type		
3.15	**Space Heater**		
i)	Make & Type		
3.16	**Wiring & Thermal Blocks**		
i)	Minimum size of conductor for a) Power wiring b) Control wiring	 mm^2 mm^2	

2.15.2 Recommended Additional Spare Parts

List hereunder the spare parts which are recommended by the Contractor for purchase in addition to the mandatory spare parts as per Chapter-15 of Volume IV, Section 7. The purchase of any or all of the recommended spare parts will be at the option of KHPL. The prices for recommended additional spare parts for five (5) years shall be quoted separately in the format provided in the Price Schedule (Section F).

Item	Description	Make/Type	Quantity
1			
2			
3			
4			

* Use additional sheets if required

2.15.3 Information to be supplied together with the Bid

At least the information listed hereunder shall be given by the Bidder. The Bidder may submit additional documents /descriptions to describe special technical features of offered equipment / system:

i) Technical offer for individual equipment

ii) Dully filled Datasheet B for individual equipment

iii) Type test certificate of all major items.

iv) General Arrangement drawing

v) Catalogues of all major items.

vi) Vendor list

vii) Transportation detail

2.15.4 Lists of Tools & Instruments

List of tools and instruments shall be listed below in additional to the list provided by the employer.

Sl. No	Item/Description	Quantity offered
1	Assembly & erection tools	
2	Testing & Commissioning tools	
3	Testing and Commissioning instruments & devices	
4	Special tools & devices needed for routine maintenance purposes	

2.15.5 Similar Installations (in last 20 years) by the Contactor

Sl. No	Description	Name of owner/utility	Quantity supplied	Year of supply/ commissioning



2.16 Uninterruptible Power Supply System

2.16.1 Guaranteed Technical Particulars

Sl. No.	Item	Unit	To be filled by bidder
1	**General Particulars**		
1.1	Name / Manufacturer/Country		
1.2	Quantity Offered	Nos.	
1.3	Type of UPS configuration		
1.4	Output Rating at ^{0}C Ambient	kVA	
1.5	Mains Input. at load PF 0.8	kVA	
1.6	Mains Tolerance Range		
i)	Voltage	%	
ii)	Frequency	%	
iii)	Combined	%	
1.7	Environment		
i)	Design Ambient Temperature Range		
a)	For Operation	^{0}C	
b)	For Storage	^{0}C	
ii)	Installation Altitude range without derating	m	
iii)	UPS Overall Efficiency	%	
2	**Enclosure**		
2.1	Sheet Thickness / Material	mm	
2.2	Degree of protection		
2.3	Mode of Cooling		
2.4	Earth Bus material & size		
2.5	Cable Entry		
2.6	From Top / Bottom		
i)	Dimensions of	LxDxH (mm)	
a)	Rectifier/ Inverter Panel		
b)	Bypass Transformer Panel		
c)	Automatic Voltage stabiliser Panel		
d)	Battery CB Panel		
e)	AC Distribution Board		
2.7	Mimic Diagram		Yes/No
2.8	Acoustics Noise Level		
i)	In Normal Mode (UPS operation)	dBA	

Sl. No.	Item	Unit	To be filled by bidder
ii)	In Stored energy Mode (Battery operation)	dBA	
2.9	Colour of Paint		
i)	Exterior		
ii)	Interior		
2.10	Weight of each Panel	kg	
3	**Rectifier**		
3.1	Ripple	% rms	
3.2	Harmonics at the point of connection to source i) THD (Voltage) ii) THD (Current)		
3.3	Type of Rectifier Bridge Circuit		
3.4	Rectifier Efficiency	%	
i)	At Half Rated Load of the System		
ii)	(At Full Rated Load of the System		
3.5	Input Power factor range		
3.6	Maximum Input current	A	
3.7	Inrush current & duration	A & sec	
4	**Inverter System**		
4.1	Type		
4.2	Output Rating at 0.8 Pf Lag at ^{0}C	kVA	
4.3	Input Nominal DC Voltage and Range	V DC	
4.4	Rated Output Current	A	
4.5	Output		
i)	Voltage	V	
ii)	Voltage adjustment range	$\pm$ %	
iii)	Steady state output voltage regulation from no-load to full load for input line variations	$\pm$ %	
a)	For balanced loads		
b)	For 20% unbalanced loads in 3-PH system		
iv)	Transient voltage regulation for 100% load application	$\pm$ %	
v)	Transient recovery time to regulating band	ms	
4.6	Frequency		
i)	Nominal frequency	Hz	
ii)	Frequency deviation range	$\pm$ %	

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Sl. No.	Item	Unit	To be filled by bidder
iii)	Synchronising adjustable range	± Hz	
iv)	Slew rate of synchronising adjustable range	Hz/Sec.	
4.7	Overload Capability		
i)	For 10 min.	% full load	
ii)	For 10 secs.	% full load	
5	**Battery**		
5.1	DC bus voltage	V	
5.2	No. of 100% capacity batteries	Nos.	
5.3	Battery backup time	Min.	
5.4	Battery capacity	AH	
5.5	Type of battery cells		
5.6	No. of battery cells	Nos.	
5.7	Battery cell / Rack dimensions	LXWXH	
6	**Static Switch**		
6.1	Rating	A	
6.2	Maximum transfer time	ms	
6.3	Short time current rating for 10 milli seconds		
7	**Stand-By Regulated Supply**		
7.1	Servo controlled Voltage Stabiliser with isolation transformer provided	Yes / No	
i)	Input volts with percentage variation allowed	V ± %	
ii)	Output volts	V	
iii)	Voltage regulation for line variation of ± 10% and 0 to 100% load variation and PF 0.8 to 1.0 range	± %	
iv)	Output voltage setting range	± %	
v)	Stabiliser continuous rating	kVA	
vi)	Isolation transformer on output side provided	Yes / No	
vii)	Input frequency with percentage variation allowed	Hz ± %	
viii)	Max Input Power	kVA	
ix)	Input current (at rated power)	A	
8	**Distribution Board**		
8.1	Single front or double front	SF /DF	
8.2	Modular construction	Yes / No	

Sl. No.	Item	Unit	To be filled by bidder
8.3	Type of outgoing feeder protection		
8.4	Total dimension of each complete switchgear L x W x D		

2.16.2 Recommended Additional Spare Parts

List hereunder the spare parts which are recommended by the Contractor for purchase in addition to the mandatory spare parts as per Chapter-16 of Volume IV, Section 7. The purchase of any or all of the recommended spare parts will be at the option of KHPL. The prices for recommended additional spare parts for five (5) years shall be quoted separately in the format provided in the Price Schedule (Section F).

Item	Description	Make/Type	Quantity
1			
2			
3			

* Use additional sheets if required

2.16.3 Information to be supplied together with the Bid

At least the information listed hereunder shall be given by the Bidder. The Bidder may submit additional documents /descriptions to describe special technical features of offered equipment / system:

i) Technical offer
ii) Dully filled Datasheet B
iii) Type test certificate.
iv) General Arrangement drawing
v) Catalogues
vi) Vendor list
vii) Transportation details

2.16.4 Lists of Tools & Instruments

List of tools and instruments shall be listed below in additional to the list provided by the employer.

Sl. No	Item/Description	Quantity offered
1	Assembly & erection tools	
2	Testing & Commissioning tools	
3	Testing and Commissioning instruments & devices	
4	Special tools & devices needed for routine maintenance purposes	

2.16.5 Similar Installations (in last 20 years) by the Contactor

Sl. No	Description	Name of owner/utility	Quantity supplied	Year of supply/ commissioning



2.17 Heat Ventilation & Air Conditioning (HVAC) System

2.17.1 Guaranteed Technical Particulars

Item No.	Parameter	Units	Contractor's Data	Remarks
1	**Chiller Units**			
1.1	Manufacturer/place of manufacture			
1.2	Type/ designation			
1.3	Applicable standard			
1.4	Number of Units	Nos.		
1.5	Unit Capacity	Tons		
1.6	Protection class	IP		
1.7	Motor service factor			
1.8	Maximum Heat load	BTU/hr, m		
1.9	Power rating	kW		
1.10	Maximum dynamic Weight	Tons/m2		
1.11	Efficiency of Chiller	%		
2	**Fresh Air Supply Units**			
2.1	Manufacturer/place of manufacture			
2.2	Applicable standard			
2.3	Type/ designation			
2.4	Number of Units	Nos.		
2.5	Unit discharge	CFM/CHM		
2.6	Duty of Motors			
2.7	Insulation class of motors			
2.8	Protection class of motors	IP		
2.9	Motor service factor			
2.10	Speed of Fans (DWDI)	rpm		
2.11	Motor rated power	kW		
2.12	Maximum dynamic Weight	Tons/m2		
2.13	Efficiency of Motor	%		
2.14	Motor speed	rpm		
3	**Air Handling Units (AHU)**			
3.1	Manufacturer/place of manufacturer			
3.2	Type/ designation			
3.3	Applicable standard			
3.4	Number of Units	Nos.		
3.5	Unit discharge	CFM/CHM		
3.6	Duty of Motors			
3.7	Insulation class of Motors			
3.8	Protection class of Motors	IP		
3.9	Motor service factor			
3.10	Speed of Fans	rpm		
3.11	Motor rated power	kW		
3.12	Maximum dynamic Weight	Tons/m2		
3.13	Efficiency of Motor	%		
3.14	Motor speed	rpm		
4	**Chilled Water Pumps**			
4.1	Manufacturer/place of manufacture			
4.2	Type/ designation			
4.3	Applicable standard			
4.4	Number of pumps	Nos.		

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Item No.	Parameter	Units	Contractor's Data	Remarks
4.5	Unit discharge at rated head	Lpm		
4.6	Duty of pump-motors			
4.7	Insulation class of pump-motors			
4.8	Protection class of pump-motors	IP		
4.9	Motor service factor			
4.10	Speed of pump	rpm		
4.11	Maximum water submergence pressure	bar		
4.12	Motor rated power	kW		
4.13	Maximum dynamic head with pumps working in isolation	m		
4.14	Maximum dynamic head with all pumps working in parallel	m		
4.15	Efficiency of			
i)	Pump	%		
ii)	Pump motor assembly	%		
iii)	Pump motor	%		
4.16	Maximum shut-off head of pumps	m		
4.17	Motor speed	rpm		
5	**Temperature sensing devices**			
5.1	Manufacturer/place of manufacture			
5.2	Type/ designation			
5.3	Applicable standard			
6	**Pressure sensing devices**			
6.1	Manufacturer/place of manufacture			
6.2	Type/ designation			
6.3	Applicable standard			
7	**Material/ Standard/Class/Grade/ Type for**			
7.1	AHU/FAS/EAU Housing			
i)	Construction Type			
ii)	Sheet Type/Grade			
iii)	Blower Covers			
iv)	Support Material			
7.2	Piping & Fittings			
i)	Pipe Material			
ii)	Insulation			
iii)	Support Material			
7.3	Ducting			
i)	Material Grade			
ii)	Support Material			
iii)	Insulation			
7.4	Fire Dampers, Grills & Volume control Dampers			
i)	Material Grade			
ii)	No of Units			
iii)	Support Material			
8	**Air Handling Units (AHU)**			
8.1	Manufacturer/place of manufacturer			
8.2	Type/ designation			
8.3	Applicable standard			
8.4	Number of Units	Nos.		
8.5	Unit discharge	CFM/CHM		

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Item No.	Parameter	Units	Contractor's Data	Remarks
8.6	Duty of Motors			
8.7	Insulation class of Motors			
8.8	Protection class of Motors	IP		
8.9	Motor service factor			
8.10	Speed of Fans	rpm		
8.11	Motor rated power	kW		
8.12	Maximum dynamic Weight	Tons/m2		
8.13	Efficiency of Motor	%		

2.17.2 Information Data

Item No.	Parameter	Units	Contractor's Data
1	**Chiller Units**		
1.1	Whether Unit characteristics value furnished	Yes/No	
1.2	Major dimensions of the Unit (LxW xH)	mm x mm x mm	
2	**FAS / AHU/ EAU/Air Curtains**		
2.1	Whether Units characteristics value furnished	Yes/No	
2.2	Major dimensions of the units (LxW xH)	mm x mm x mm	
3	**Chilled Water Pumps**		
3.1	Whether pump characteristics value furnished	Yes/No	
3.2	Major dimensions of the pumps (LxW xH)	mm x mm x mm	
4	**Ducting Sheets**		
4.1	Whether Used GSS Sheets values furnished	Yes/No	
4.2	Major dimensions of the Sheets (LxW xH)	mm x mm x mm	
5	**General (applicable to all HVAC System)**		
5.1	If any		

2.17.3 Recommended Additional Spare Parts

List hereunder the spare parts which are recommended by the Contractor for purchase in addition to the mandatory spare parts as per Chapter-17 of Volume IV, Section 7. The purchase of any or all of the recommended spare parts will be at the option of KHPL. The prices for recommended additional spare parts for five (5) years shall be quoted separately in the format provided in the Price Schedule (Volume 3).

Item	Description	Make/Type	Quantity
1			
2			
3			
4			

* Use additional sheets if required

2.17.4 Information to be supplied together with the Bid

At least the information listed hereunder shall be given by the Bidder. The Bidder may submit additional documents /descriptions to describe special technical features of offered equipment / system:

i. Pamphlets of the proposed pumps giving at least the following information

a. Pump flow characteristics

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b. Cross section of pump with motor

ii. Pamphlets of the proposed level sensing devices and level transducer giving the technical particulars and other operational and installation features.

2.17.5 Lists of Tools & Instruments

List of tools and instruments in accordance to the clause17.16 of PTS Chapter-17 under Section-7 of Volume-4 shall be listed below in additional to the list provided by the employer.

Sl. No	Item/Description	Quantity offered
1	Assembly & erection tools	
2	Testing & Commissioning tools	
3	Testing and Commissioning instruments & devices	
4	Special tools & devices needed for routine maintenance purposes	

2.17.6 Similar Installations (in last 20 years) by the Contactor

Sl. No	Description	Name of owner/utility	Quantity supplied	Year of supply/ commissioning

2.18 Cables & Cabling System

2.18.1 Guaranteed Technical Particulars

Sl. No.	Description	Unit	To Be Filled By Bidder	
1	**Cabling System**			
1.1	Cables			
i)	Manufacturers name			
ii)	Whether cores identified by Numerals for cables with 5 core and above	Yes / No		
iii)	Whether incremental running lengths are marked on cable	Yes / No		
iv)	Whether the cables comply with specification requirement	Yes / No		
v)	Group derating factor for HV cables laid in air			
vi)	Group derating factor for HV cables laid in sand filled cable trench			
vii)	Group derating factor for LV Power cables laid in air			
viii)	Group derating factor for LV Power cables laid in sand filled cable trench			
ix)	Applicable standards			
1.2	**HV Cable termination and straight through joint kits**			
i)	Nominal (Phase to phase) System Voltages	kV	11	33
ii)	A.C withstand voltage (Ph / Ground)	kV		
iii)	Time duration	mins		
iv)	Partial discharge at 2 Uo	pC		
v)	Impulse withstand, 1.2 / 50 µs	kV		
vi)	Load cycle test			
a)	Each cycle – heating - duration	Hrs		
	• Temperature	^{0}C		
	• Cooling duration	Hrs		
b)	Number of cycles			
c)	Continuous phase to ground voltage withstand	kV		
i)	Thermal withstand short circuit current 1 sec.	kA		
ii)	Dynamic short circuit withstand	kA/peak		
iii)	Type test report for all the tests enclosed	Yes / No		
1.3	**Cable carrier system**			
i)	Type of cable carrier system offered			
ii)	All cable carrier steel components are hot dip galvanised	Yes / No		
1.4	Fire proof sealing system offered			
1.5	Type of glands			
1.6	Type of lugs			

2.18.2 Recommended Additional Spare Parts

List hereunder the spare parts which are recommended by the Contractor for purchase in addition to the mandatory spare parts as per Chapter-18 of Volume IV, Section 7. The purchase of any or all of the recommended spare parts will be at the option of KHPL. The prices for recommended additional spare parts for five (5) years shall be quoted separately in the format provided in the Price Schedule (Section F).

Item	Description	Make/Type	Quantity
1			
2			
3			
4			

* Use additional sheets if required

2.18.3 Information to be supplied together with the Bid

At least the information listed hereunder shall be given by the Bidder. The Bidder may submit additional documents /descriptions to describe special technical features of offered equipment / system:

i) Technical offer

ii) Data sheet for cables

iii) Type and routine test certificate

iv) Cables and cabling system-Bill of quantity.

v) Vendor list for various components, fittings and accessories.

vi) Transportation details

2.18.4 Lists of Tools & Instruments

List of tools and instruments shall be listed below in additional to the list provided by the employer.

Sl. No	Item/Description	Quantity offered
1	Assembly & erection tools	
2	Testing & Commissioning tools	
3	Testing and Commissioning instruments & devices	
4	Special tools & devices needed for routine maintenance purposes	

2.18.5 Similar Installations (in last 20 years) by the Contactor

Sl. No	Description	Name of owner/utility	Quantity supplied	Year of supply/ commissioning



2.19 Electric Overhead Travelling (EOT) Crane

2.19.1 Guaranteed Technical Particulars

Item No.	Parameter	Units	Contractor's Data	Remarks
1	**Powerhouse EOT crane**			
1.1	Manufacturer/place of manufacture			
1.2	Type/ designation			
1.3	Applicable Standard			
1.4	Number of cranes	Nos.		
1.5	Duty class of cranes			
1.6	Rated capacity of			
i)	Main hoist	tonnes		
ii)	Auxiliary hoist	tonnes		
iii)	Monorail hoist	tonnes		
1.7	Crane span (centre to centre of rails)	m		
1.8	Total lift of			
i)	Main hoist	m		
ii)	Auxiliary hoist	m		
iii)	Monorail hoist	m		
1.9	Normal operating speeds (at rated load)			
i)	Bridge travel (long)	m/min.		
ii)	Trolley travel (cross)	m/min.		
iii)	Main hoist lift / lower	m/min.		
iv)	Auxiliary hoist lift / lower	m/min.		
v)	Monorail Hoist lift/lower	m/min.		
1.10	Creeping speeds (at rated load)			
i)	Bridge travel (long)	%		
ii)	Trolley travel (close)	%		
iii)	Main hoist lift/lower	%		
iv)	Auxiliary hoist life/lower	%		
1.11	Jog movement			
i)	Bridge travel (long)	mm		
ii)	Trolley travel (close)	mm		
iii)	Main hoist lift/lower	mm		
iv)	Auxiliary hoist life/lower	mm		
1.12	Total lift (from service bay)			
i)	Main hook	m		
ii)	Auxiliary hook	m		
1.13	Acceleration / deceleration			
i)	Bridge travel	m/sec^2		
ii)	Trolley travel	m/sec^2		
1.14	Maximum vertical deflection of bridge girder at rated load including dead load	mm		
1.15	Speed Regulation			
i)	From	%		
ii)	To	%		

Item No.	Parameter	Units	Contractor's Data	Remarks
1.16	Minimum incremental movement of			
i)	Main hoist	mm		
ii)	Auxiliary hoist	mm		
iii)	Bridge Travel	mm		
iv)	Trolley Travel	mm		
1.17	Crane motors			
i)	Type			
ii)	Insulation class and protection class			
iii)	Relative duty factor of motor for normal speed			
1.18	Maximum distance between bottom of gantry rail and the highest point of the crane	mm		
1.19	Lowest factor of safety (referred to yield strength)			
i)	For most strained structural part			
ii)	For wire rope			
1.20	Test load			
i)	On main hoist	tonnes		
ii)	On auxiliary hoist	tonnes		
iii)	Mono rail hoist	tonnes		
1.21	Typical value of unit stresses assumed on most critical items (with designation)	N/mm^2		
1.22	Radio remote control			
i)	Manufacturer			
ii)	Type of transmitter			
iii)	Type of receiver			
iv)	Battery charger for transmitter battery charging furnished	Yes/No		
v)	Standard to which conforms			
vi)	Detail write-up/catalogue furnished	Yes/No		
vii)	Operating distance	m		
viii)	Degree of protection	IP		
2	**GIS cavern EOT crane**			
2.1	Manufacturer/place of manufacture			
2.2	Type/ designation			
2.3	Applicable Standard			
2.4	Number of cranes	Nos.		
2.5	Duty class of cranes			
2.6	Rated capacity of hoist	tonnes		
2.7	Crane span (centre to centre of rails)	m		
2.8	Total lift of hook	m		
2.9	Normal operating speeds (at rated load) for hook lift/lower	m/min		

Item No.	Parameter	Units	Contractor's Data	Remarks
2.10	Creeping speeds (at rated load)			
i)	Bridge travel (long)	%		
ii)	Trolley travel (close)	%		
iii)	Hoist lift/lower	%		
2.11	Jog movement			
i)	Bridge travel (long)	mm		
ii)	Trolley travel (close)	mm		
iii)	Hoist lift/lower	mm		
2.12	Total lift of hoist (from transformer floor)	m		
2.13	Acceleration / deceleration			
i)	Bridge travel	m/sec^2		
ii)	Trolley travel	m/sec^2		
2.14	Maximum vertical deflection of bridge girder at rated load including dead load	mm		
2.15	Speed Regulation			
i)	From	%		
ii)	To	%		
2.16	Minimum incremental movement of hoist	mm		
2.17	Crane motors			
i)	Type			
ii)	Insulation class and protection class			
iii)	Relative duty factor of motor for normal speed			
2.18	Maximum distance between bottom of gantry rail and the highest point of the crane	mm		
2.19	Lowest factor of safety (referred to yield strength)			
i)	For most strained structural part			
ii)	For wire rope			
2.20	Test load on hoist	tonnes		
2.21	Typical value of unit stresses assumed on most critical items (with designation)	N/mm^2		
2.22	Radio remote control			
i)	Manufacturer			
ii)	Type of transmitter			
iii)	Type of receiver			
iv)	Battery charger for transmitter battery charging furnished	Yes/No		
v)	Standard to which conforms			
vi)	Detail write-up/catalogue furnished	Yes/No		
vii)	Operating distance	m		
viii)	Degree of protection	IP		
3	**Butterfly valve cavern EOT crane**			

Item No.	Parameter	Units	Contractor's Data	Remarks
3.1	Manufacturer/place of manufacture			
3.2	Type/ designation			
3.3	Applicable Standard			
3.4	Number of cranes	Nos.		
3.5	Duty class of cranes			
3.6	Rated capacity of			
i)	Main hoist	tonnes		
ii)	Auxiliary hoist	tonnes		
3.7	Crane span (centre to centre of rails)	m		
3.8	Total lift of			
i)	Main hook	m		
ii)	Auxiliary hook	m		
3.9	Normal operating speeds (at rated load)			
i)	Bridge travel (long)	m/min.		
ii)	Trolley travel (cross)	m/min.		
iii)	Main hoist lift / lower	m/min.		
iv)	Auxiliary hoist lift / lower	m/min.		
3.10	Creeping speeds (at rated load)			
i)	Bridge travel (long)	%		
ii)	Trolley travel (close)	%		
iii)	Main hoist lift/lower	%		
iv)	Auxiliary hoist life/lower	%		
3.11	Jog movement			
i)	Bridge travel (long)	mm		
ii)	Trolley travel (close)	mm		
iii)	Main hoist lift/lower	mm		
iv)	Auxiliary hoist life/lower	mm		
3.12	Total lift (from valve house floor)			
i)	Main hook	m		
ii)	Auxiliary hook	m		
3.13	Acceleration / deceleration			
i)	Bridge travel	m/sec^2		
ii)	Trolley travel	m/sec^2		
3.14	Maximum vertical deflection of bridge girder at rated load including dead load	mm		
3.15	Speed Regulation			
i)	From	%		
ii)	To	%		
3.16	Minimum incremental movement of			
i)	Main hoist	mm		
ii)	Auxiliary hoist	mm		
iii)	Bridge Travel	mm		
iv)	Trolley Travel	mm		

Item No.	Parameter	Units	Contractor's Data	Remarks
3.17	Crane motors			
i)	Type			
ii)	Insulation class and protection class			
iii)	Relative duty factor of motor for normal speed			
3.18	Maximum distance between bottom of gantry rail and the highest point of the crane	mm		
3.19	Lowest factor of safety (referred to yield strength)			
i)	For most strained structural part			
ii)	For wire rope			
3.20	Test load			
i)	On main hoist	tonnes		
ii)	On auxiliary hoist	tonnes		
3.21	Typical value of unit stresses assumed on most critical items (with designation)	N/mm^2		
3.22	Radio remote control			
i)	Manufacturer			
ii)	Type of transmitter			
iii)	Type of receiver			
iv)	Battery charger for transmitter battery charging furnished	Yes/No		
v)	Standard to which conforms			
vi)	Detail write-up/catalogue furnished	Yes/No		
vii)	Operating distance	m		
viii)	Degree of protection	IP		

2.19.2 Informative Data

Item No.	Parameter	Units	Contractor's Data	Remarks
1	**Powerhouse EOT Crane**			
1.1	Factor of safety for;			
i)	Crane structure			
ii)	wire rope			
iii)	Crane mechanism			
iv)	Rope drum			
1.2	Bridge travel mechanism			
i)	Number of motors			
a)	Normal speed			
b)	Creeping speed			
ii)	Rated power of motor			
a)	Normal speed			
b)	Creeping speed			
iii)	Rated voltage and frequency			
a)	Normal speed	V/Hz		

Item No.	Parameter	Units	Contractor's Data	Remarks
b)	Creeping speed	V/Hz		
iv)	Relative duty factor			
a)	Normal speed			
b)	Creeping speed			
v)	Wheels			
a)	Number of wheels on each side	nos.		
b)	Minimum Brignell hardness	BHN		
c)	Minimum diameter of wheel	mm		
vi)	Type of brake provided			
1.3	Trolley drive mechanism			
i)	Number of motors			
a)	Normal speed			
b)	Creeping speed			
ii)	Rated power of motor			
a)	Normal speed			
b)	Creeping speed			
iii)	Rated voltage and frequency			
a)	Normal speed	V/Hz		
b)	Creeping speed	V/Hz		
iv)	Relative duty factor			
a)	Normal speed			
b)	Creeping speed			
v)	Wheels			
a)	Number of wheels on each side	nos.		
b)	Minimum Brignell hardness	BHN		
c)	Minimum diameter of wheel	mm		
vi)	Type of brake provided			
1.4	Hoisting Mechanism of Main Hook			
i)	Number of motors			
a)	Normal speed			
b)	Creeping speed			
ii)	Rated power of motor			
a)	Normal speed			
b)	Creeping speed			
iii)	Rated voltage and frequency			
a)	Normal speed	V/Hz		
b)	Creeping speed	V/Hz		
iv)	Relative duty factor			
a)	Normal speed			
b)	Creeping speed			
v)	Wheels			
a)	Number of wheels on each side	nos.		
b)	Minimum Brignell hardness	BHN		
c)	Minimum diameter of wheel	mm		
vi)	Type of load brake			
vii)	Type of holding brake			

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Item No.	Parameter	Units	Contractor's Data	Remarks
1.5	Hoisting Mechanism of Auxiliary Hook			
i)	Number of motors			
a)	Normal speed			
b)	Creeping speed			
ii)	Rated power of motor			
a)	Normal speed			
b)	Creeping speed			
iii)	Rated voltage and frequency			
a)	Normal speed	V/Hz		
b)	Creeping speed	V/Hz		
iv)	Relative duty factor			
a)	Normal speed			
b)	Creeping speed			
v)	Wheels			
a)	Normal speed	nos.		
b)	Creeping speed	BHN		
c)	Normal speed	mm		
vi)	Type of load brake			
vii)	Type of holding brake			
1.6	Hoisting Mechanism of Monorail Hook			
i)	Number of motors			
a)	Normal speed			
b)	Creeping speed			
ii)	Rated power of motor			
a)	Normal speed			
b)	Creeping speed			
iii)	Rated voltage and frequency			
a)	Normal speed	V/Hz		
b)	Creeping speed	V/Hz		
iv)	Relative duty factor			
a)	Normal speed			
b)	Creeping speed			
v)	Wheels			
a)	Number of wheels on each side	nos.		
b)	Minimum Brignell hardness	BHN		
c)	Minimum diameter of wheel	mm		
vi)	Type of load brake			
vii)	Type of holding brake			
1.7	Maximum slenderness ratio of members of the girder			
1.8	Bearings			
i)	Type of bearings for LT/CT/MH/AH/mono motors and gear boxes			
ii)	Minimum service life	Hrs		

Item No.	Parameter	Units	Contractor's Data	Remarks
1.9	Type of controls used	Cabin/ pendant/ radio		
1.10	Terminal position of			
i)	Main hook from centre of gantry rail			
a)	Upstream side	mm		
b)	Downstream side	mm		
ii)	Auxiliary hook from centre of gantry rail			
a)	Upstream side	mm		
b)	Downstream side	mm		
iii)	Monorail hook from centre of gantry rail			
a)	Upstream side	mm		
b)	Downstream side	mm		
iv)	Main hook from inner edge of wall at			
c)	service bay wall	mm		
d)	other end	mm		
v)	Auxiliary hook from inner edge of wall at			
e)	service bay wall	mm		
f)	other end	mm		
vi)	Type			
g)	service bay wall	mm		
h)	other end	mm		
vii)	Hooks at maximum lift below top of runway rail			
i)	of main hook	mm		
j)	of auxiliary hook	mm		
1.11	Load per wheel			
a)	Maximum vertical static load	KN		
b)	Maximum vertical dynamic load	KN		
c)	Maximum vertical test load	KN		
d)	Maximum horizontal load perpendicular to wheel	KN		
e)	Maximum horizontal load parallel to rail	KN		
1.12	Total power supply requirement for crane	kW		
1.13	Whether VVVF drive has been provided for all motion	Yes/No		
1.14	Sufficiency in capacity to handle generator rotor with lifting beam	Yes / No		
1.15	Weights			
i)	Weight of complete crane (excl. Rails)	Kg		
ii)	Heaviest part for erection- designation / weight	Designation / Kg		
iii)	Weight of Girders	Kg		

Item No.	Parameter	Units	Contractor's Data	Remarks
1.16	Material/ standard/ class/ grade/ type for			
i)	Girder			
ii)	Trolley			
iii)	End truck			
iv)	Rope Drum			
v)	Wheel			
vi)	Hook			
vii)	Sheave			
viii)	Pulleys			
1.17	Equalizer beam for tandem operation			
i)	Material standard			
ii)	Design standard			
iii)	Factor of safety of equalizer beam			
2	**Butterfly valve house EOT Crane**			
2.1	Factor of safety for;			
i)	Crane structure			
ii)	Wire rope			
iii)	Crane mechanism			
iv)	Rope drum			
2.2	Bridge travel mechanism			
i)	Number of motors			
a)	Normal speed			
b)	Creeping speed			
ii)	Rated power of motor			
a)	Normal speed			
b)	Creeping speed			
iii)	Rated voltage and frequency			
a)	Normal speed	V/Hz		
b)	Creeping speed	V/Hz		
iv)	Relative duty factor			
a)	Normal speed			
b)	Creeping speed			
v)	Wheels			
a)	Number of wheels on each side	nos.		
b)	Minimum Brignell hardness	BHN		
c)	Minimum diameter of wheel	mm		
vi)	Type of brake provided			
2.3	Trolley drive mechanism			
i)	Number of motors			
a)	Normal speed			
b)	Creeping speed			
ii)	Rated power of motor			
a)	Normal speed			
b)	Creeping speed			
iii)	Rated voltage and frequency			
a)	Normal speed	V/Hz		

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Item No.	Parameter	Units	Contractor's Data	Remarks
b)	Creeping speed	V/Hz		
iv)	Relative duty factor			
a)	Normal speed			
b)	Creeping speed			
v)	Wheels			
a)	Number of wheels on each side	nos.		
b)	Minimum Brignell hardness	BHN		
c)	Minimum diameter of wheel	mm		
vi)	Type of brake provided			
2.4	Hoisting Mechanism of Main Hook			
i)	Number of motors			
a)	Normal speed			
b)	Creeping speed			
ii)	Rated power of motor			
a)	Normal speed			
b)	Creeping speed			
iii)	Rated voltage and frequency			
a)	Normal speed	V/Hz		
b)	Creeping speed	V/Hz		
iv)	Relative duty factor			
a)	Normal speed			
b)	Creeping speed			
v)	Wheels			
a)	Normal speed	nos.		
b)	Creeping speed	BHN		
c)	Normal speed	mm		
vi)	Type of load brake			
vii)	Type of holding brake			
2.5	Hoisting Mechanism of Auxiliary Hook			
i)	Number of motors			
a)	Normal speed			
b)	Creeping speed			
ii)	Rated power of motor			
a)	Normal speed			
b)	Creeping speed			
iii)	Rated voltage and frequency			
a)	Normal speed	V/Hz		
b)	Creeping speed	V/Hz		
iv)	Relative duty factor			
a)	Normal speed			
b)	Creeping speed			
v)	Wheels			
a)	Number of wheels on each side	Nos.		
b)	Minimum Brignell hardness	BHN		
c)	Minimum diameter of wheel	mm		
vi)	Type of load brake			

Item No.	Parameter	Units	Contractor's Data	Remarks
vii)	Type of holding brake			
2.6	Maximum slenderness ratio of members of the girder			
2.7	Bearings			
i)	Type of bearings for LT/CT/MH/AH/mono motors and gear boxes			
ii)	Minimum service life	Hrs		
2.8	Type of controls used	Cabin/ pendant/ radio		
2.9	Terminal position of			
i)	Main hook from centre of gantry rail on			
a)	Unloading area side	mm		
b)	Other side	mm		
ii)	Auxiliary hook from centre of gantry rail on			
a)	Unloading area side	mm		
b)	Other side	mm		
iii)	Main hook from inner edge of wall at			
a)	Unloading area side	mm		
b)	Other side	mm		
iv)	Auxiliary hook from inner edge of wall at			
a)	Unloading area side	mm		
b)	Other side	mm		
v)	Hooks at maximum lift below top of runway rail			
a)	Of main hook	mm		
b)	Of auxiliary hook	mm		
2.10	Load per wheel			
i)	Maximum vertical static load	KN		
ii)	Maximum vertical dynamic load	KN		
iii)	Maximum vertical test load	KN		
iv)	Maximum horizontal load perpendicular to wheel	KN		
v)	Maximum horizontal load parallel to rail	KN		
2.11	Total power supply requirement for crane	kW		
2.12	Whether VVVF drive has been provided for all motion	Yes/No		
2.13	Weights			
i)	Weight of complete crane (excl. Rails)	Kg		
ii)	Heaviest part for erection-designation / weight	Designation / Kg		
iii)	Weight of girders	Kg		

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Item No.	Parameter	Units	Contractor's Data	Remarks
2.14	Material/ standard/ class/ grade/ type for			
i)	Girder			
ii)	Trolley			
iii)	End truck			
iv)	Rope Drum			
v)	Wheel			
vi)	Hook			
vii)	Sheave			
viii)	Pulleys			
3	**GIS cavern EOT Crane**			
3.1	Factor of safety for;			
i)	Crane structure			
ii)	wire rope			
iii)	Crane mechanism			
iv)	Rope drum			
3.2	Bridge travel mechanism			
i)	Number of motors			
a)	Normal speed			
b)	Creeping speed			
ii)	Rated power of motor			
a)	Normal speed			
b)	Creeping speed			
iii)	Rated voltage and frequency			
a)	Normal speed	V/Hz		
b)	Creeping speed	V/Hz		
iv)	Relative duty factor			
a)	Normal speed			
b)	Creeping speed			
v)	Wheels			
a)	Number of wheels on each side	nos.		
b)	Minimum Brignell hardness	BHN		
c)	Minimum diameter of wheel	mm		
vi)	Type of brake provided			
3.3	Trolley drive mechanism			
i)	Number of motors			
a)	Normal speed			
b)	Creeping speed			
ii)	Rated power of motor			
a)	Normal speed			
b)	Creeping speed			
iii)	Rated voltage and frequency			
a)	Normal speed	V/Hz		
b)	Creeping speed	V/Hz		
iv)	Relative duty factor			
a)	Normal speed			
b)	Creeping speed			

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Item No.	Parameter	Units	Contractor's Data	Remarks
v)	Wheels			
a)	Number of wheels on each side	nos.		
b)	Minimum Brignell hardness	BHN		
c)	Minimum diameter of wheel	mm		
vi)	Type of brake provided			
3.4	Hoisting Mechanism of Hook			
i)	Number of motors			
a)	Normal speed			
b)	Creeping speed			
ii)	Rated power of motor			
a)	Normal speed			
b)	Creeping speed			
iii)	Rated voltage and frequency			
a)	Normal speed	V/Hz		
b)	Creeping speed	V/Hz		
iv)	Relative duty factor			
a)	Normal speed			
b)	Creeping speed			
v)	Wheels			
a)	Number of wheels on each side	nos.		
b)	Minimum Brignell hardness	BHN		
c)	Minimum diameter of wheel	mm		
vi)	Type of load brake			
vii)	Type of holding brake			
3.5	Maximum slenderness ratio of members of the girder			
3.6	Bearings			
i)	Type of bearings for LT/CT/MH/AH/mono motors and gear boxes			
ii)	Minimum service life	Hrs		
3.7	Type of controls used	Cabin/ pendant/ radio		
3.8	Total power supply requirement for crane	kW		
3.9	Whether VVVF drive has been provided for all motion	Yes/No		
3.10	Weights			
i)	Weight of complete crane (excl. Rails)	Kg		
ii)	Heaviest part for erection-designation / weight	Designation / Kg		
iii)	Weight of girders	Kg		
3.11	Material/ standard/ class/ grade/ type for			
i)	Girder			
ii)	Trolley			
iii)	End truck			

Item No.	Parameter	Units	Contractor's Data	Remarks
iv)	Rope Drum			
v)	Wheel			
vi)	Hook			
vii)	Sheave			
viii)	Pulleys			

2.19.3 Recommended Additional Spare Parts

List hereunder the spare parts which are recommended by the Contractor for purchase in addition to the mandatory spare parts as per Chapter-19 of Volume IV, Section 7. The purchase of any or all of the recommended spare parts will be at the option of KHPL. The prices for recommended additional spare parts for five (5) years shall be quoted separately in the format provided in the Price Schedule (Volume 3).

Item	Description	Make/Type	Quantity
1			
2			
3			
4			

* Use additional sheets if required

2.19.4 Information to be supplied together with the Bid

At least the information listed hereunder shall be given by the Bidder. The Bidder may submit additional documents /descriptions to describe special technical features of offered equipment / system:

Dimensional drawings of the cranes showing:

i) Main dimensions

ii) Approach distances on all four sides for main hook, auxiliary hook and monorail hook.

iii) Coupling arrangement for tandem operation with Equalizer beam.

2.19.5 Lists of Tools & Instruments

List of tools and instruments in accordance to the clause 19.14 of PTS Chapter-19 under Section-7 of Volume-4 shall be listed below in additional to the list provided by the employer.

Sl. No	Item/Description	Quantity offered
1	Assembly & erection tools	
2	Testing & Commissioning tools	
3	Testing and Commissioning instruments & devices	
4	Special tools & devices needed for routine maintenance purposes	

2.19.6 Similar Installations (in last 20 years) by the Contactor

Sl. No	Description	Name of owner/utility	Quantity supplied	Year of supply/ commissioning

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2.20 Fire protection System

2.20.1 Guaranteed Technical Particulars

Item No.	Parameter	Units	Contractor's Data	Remarks
1	**Hydrants (External/Internal)**			
1.1	Manufacturer/place of manufacture			
1.2	Type/ designation			
1.3	Applicable standard			
1.4	Number of Units	Nos.		
1.5	Sizes	mm		
2	**HVWS**			
2.1	Manufacturer/place of manufacture			
2.2	Applicable standard			
2.3	Type/ designation			
2.4	Number of Units	Nos.		
2.5	Sizes	mm		
2.6	Working Pressure	bar		
2.7	DV Nos	Nos		
2.8	DV Sizes	mm		
3	**MVWS**			
3.1	Manufacturer/place of manufacturer			
3.2	Type/ designation			
3.3	Applicable standard			
3.4	Number of Units	Nos.		
3.5	Sizes	mm		
3.6	Working Pressure	bar		
3.7	DV Nos	Nos		
3.8	DV Sized	mm		
4	**Piping & Fittings**			
4.1	Manufacturer/place of manufacture			
4.2	Type/ designation			
4.3	Applicable standard			
4.4	Used Pipe Sizes	mm		
4.5	Pipe Material			
4.6	Air Release Valves Nos	Nos		
4.7	Pressure Gauges			
4.8	Gate Vales	Nos		
4.9	Non-Return Valves	Nos		
4.10	Filters Type			
4.11	Filters	Nos		
4.12	Filter Sizes	microns		
4.13	Support Material			
5	**Water Tank**			
5.1	Tank Capacity			
5.2	Required Pressure			
5.3	Applicable standard			
6	**Draw Off**			
6.1	Manufacturer/place of manufacture			
6.2	Type/ designation			

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Item No.	Parameter	Units	Contractor's Data	Remarks
6.3	Applicable standard			
6.4	Material			
7	**Fire Brigade**			
7.1	Manufacturer/place of manufacture			
7.2	Type/ designation			
7.3	Applicable standard			
7.4	Material			
8	**Hydrant Hose**			
8.1	Manufacturer/place of manufacture			
8.2	Type/ designation			
8.3	Applicable standard			
8.4	Sizes			

2.20.2 Information Data

Item No.	Parameter	Units	Contractor's Data
1	**Hydrant**		
1.1	Whether Unit characteristics value furnished	Yes/No	
1.2	Major dimensions of the Cabinet (LxW xH)	mm x mm x mm	
2	**Deluge Valve (DV)**		
2.1	Whether DV characteristics value furnished	Yes/No	
2.2	Major dimensions of the DV (LxW xH)	mm x mm x mm	
3	**Pipes & Fittings**		
3.1	Whether Material Data sheets furnished	Yes/No	
3.2	Major dimensions of the Pipes& Fittings (LxW xH)	mm x mm x mm	
4	**General (applicable to all Fire Protection System)**		
4.1	If any		

2.20.3 Recommended Additional Spare Parts

List hereunder the spare parts which are recommended by the Contractor for purchase in addition to the mandatory spare parts as per Chapter-20 of Volume IV, Section 7. The purchase of any or all of the recommended spare parts will be at the option of KHPL. The prices for recommended additional spare parts for five (5) years shall be quoted separately in the format provided in the Price Schedule (Volume 3).

Item	Description	Make/Type	Quantity
1			
2			
3			
4			

* Use additional sheets if required

2.20.4 Information to be supplied together with the Bid

At least the information listed hereunder shall be given by the Bidder. The Bidder may submit additional documents /descriptions to describe special technical features of offered equipment / system:

i. Pamphlets of the proposed pumps giving at least the following information

   a. Pump flow characteristics

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b. Cross section of pump with motor

ii. Pamphlets of the proposed level sensing devices and level transducer giving the technical particulars and other operational and installation features.

2.20.5 Lists of Tools & Instruments

List of tools and instruments in accordance to the clause 20.10 of PTS Chapter-20 under Section-7 of Volume-4 shall be listed below in additional to the list provided by the employer.

Sl. No	Item/Description	Quantity offered
1	Assembly & erection tools	
2	Testing & Commissioning tools	
3	Testing and Commissioning instruments & devices	
4	Special tools & devices needed for routine maintenance purposes	

2.20.6 Similar Installations (in last 20 years) by the Contactor

Sl. No	Description	Name of owner/utility	Quantity supplied	Year of supply/ commissioning

2.21 Fire Detection & Alarm System

2.21.1 Guaranteed Technical Particulars

Sl. No.	Description	Unit	To Be Filled By Bidder
1	**General**		
i)	Resetability of detectors		
ii)	Interchange ability of detectors		
iii)	Response Indicator operation a) Lights up steadily to indicate healthy condition b) Flashes Intermittently under alarm condition		
iv)	Test facility of Detectors		
v)	Label on detectors		
vi)	Mounting facilities of Detectors		
vii)	POWER SUPPLY		
a)	Main fire alarm panel/ Sub fire alarm panels		
b)	Repeater Panels		
c)	Fire siren		
viii)	Paint shade for Panels		
ix)	Degree of protection for panels		
x)	Range/location of fire sirens		
2	**Manual call points**		
i)	Make		
ii)	Model No.		
iii)	Type of glass provided on the manual call point for flame proof units.		
iv)	Degree of protection of enclosure		
3	**Multi sensor detector**		
i)	Make		
ii)	Model No.		
iii)	Application Standards		
iv)	Sensitivity / Response threshold value		
v)	Maximum and minimum mounting height at which the detector operates satisfactorily.		
vi)	Listed spacing of detectors		
4	**Beam detector**		
i)	Make		
ii)	Model No.		
iii)	Application Standards		
iv)	Coverage area		
5	**Addressable Interface Unit**		
i)	Make		
ii)	Model No.		
iii)	Applicable Standards		
iv)	Maximum number of non-addressable group of detectors / devices and MCP that can be connected to an addressable unit		
6	**Electronic Hooters**		

Sl. No.	Description	Unit	To Be Filled By Bidder
i)	Make		
ii)	Model No.		
iii)	Applicable Standards		
iv)	Type of Hooter		
v)	Type of tone		
vi)	Sound level		
vii)	Illumination Level		
viii)	Range of Hooter		
ix)	Power supply required for Hooter		
7	**Fire Alarm Panels**		
i)	Make		
ii)	Model No.		
iii)	Applicable Standards		
iv)	Degree of protection		
v)	Batteries		
vi)	Battery capacity		
vii)	Central Processing Unit (CPU) Provided in Fire alarm panel		
a)	Make		
b)	Model No.		
c)	Applicable Standards		
d)	Whether redundant processor provided.		
viii)	Integral HMI / Display unit on Fire alarm panel		
ix)	Whether Auto dialler provided		
8	**Cables**		
i)	Make		
ii)	Type		
iii)	Voltage Grade		

2.21.2 Recommended Additional Spare Parts

List hereunder the spare parts which are recommended by the Contractor for purchase in addition to the mandatory spare parts as per Chapter-21 of Volume IV, Section 7. The purchase of any or all of the recommended spare parts will be at the option of KHPL. The prices for recommended additional spare parts for five (5) years shall be quoted separately in the format provided in the Price Schedule (Section F).

Item	Description	Make/Type	Quantity
1			
2			
3			
4			

* Use additional sheets if required

2.21.3 Information to be supplied together with the Bid

At least the information listed hereunder shall be given by the Bidder. The Bidder may submit additional documents /descriptions to describe special technical features of offered equipment / system:

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i) Technical offer
ii) Dully filled Datasheet B
iii) Type test certificate.
iv) General Arrangement drawing
v) Catalogues
vi) Vendor list
vii) Transportation details

2.21.4 Lists of Tools & Instruments

List of tools and instruments shall be listed below in additional to the list provided by the employer.

Sl. No	Item/Description	Quantity offered
1	Assembly & erection tools	
2	Testing & Commissioning tools	
3	Testing and Commissioning instruments & devices	
4	Special tools & devices needed for routine maintenance purposes	

2.21.5 Similar Installations (in last 20 years) by the Contactor

Sl. No	Description	Name of owner/utility	Quantity supplied	Year of supply/ commissioning

2.22 MV Switchgear

2.22.1 Guaranteed Technical Particulars

A) 11 kV Switchgears at Powerhouse

Sl. No.	Description	Unit	To Be Filled By Bidder
1	Manufacturer/s name		
2	Applicable standards		
3	Type of circuit breaker		
4	Max. continuous voltage	kVrms	
4.1	Switchboard		
4.2	Breaker		
4.3	CT / VT		
5	Impulse withstand voltage / PF withstand voltage	kVp / kVrms	
5.1	Switchboard		
5.2	Breaker		
5.3	CT / VT		
6	SC current withstand capability (current / duration)	kA / sec	
6.1	Switchboard		
6.2	Breaker		
6.3	CT		
7	Momentary current withstand	kAp	
8	Degree of protection for switchboard		
8.1	Bus bar compartment		
8.2	Other compartment		
9	Bus bar		
9.1	Material		
9.2	Continuous current rating under site conditions		
9.3	Temperature rise over the design ambient of 50ºC		
10	Circuit breaker		
10.1	Manufacturer		
10.2	Type of circuit breaker		
10.3	Rated symmetrical breaking	kA	
10.4	Making current	kAp	
10.5	Rated S.C current withstand & duration	kA Sec	
10.6	One minute power frequency withstand voltage	kA	
10.7	Impulse withstand voltage	kVp	
10.8	Duty cycle		
10.9	Total break time	msec	
10.10	Make time	msec	

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Sl. No.	Description	Unit	To Be Filled By Bidder
10.11	Switching over voltages generated and time to crest while switching off unloaded transformer	kVp /µsec	
10.12	Type of external switching over voltage limiting device provided		
10.13	Type of operating mechanism		
11	PTS		
11.1	Make		
11.2	Rated voltage factor		
i)	Continuous		
ii)	8 hours		
12	Earthing arrangement for		
12.1	Bus bar		
12.2	Cables		
13	Bus section isolator		
13.1	Type		
13.2	Rated current		
13.3	One min power frequency withstand voltage	kVrms	
13.4	1.2/50µsec impulse withstand voltage	KVp	
13.5	Minimum no. of auxiliary contacts		

B) 11 kV Switchgears at Pothead yard

Sl. No.	Description	Unit	To Be Filled By Bidder
1	Manufacturer/s name		
2	Applicable standards		
3	Type of circuit breaker		
4	Max. continuous voltage	kVrms	
4.1	Switchboard		
4.2	Breaker		
4.3	CT / VT		
5	Impulse withstand voltage / PF withstand voltage	kVp / kVrms	
5.1	Switchboard		
5.2	Breaker		
5.3	CT / VT		
6	SC current withstand capability (current / duration)	kA / sec	
6.1	Switchboard		
6.2	Breaker		
6.3	CT		
7	Momentary current withstand	kAp	
8	Degree of protection for switchboard		
8.1	Bus bar compartment		
8.2	Other compartment		
9	Bus bar		

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Sl. No.	Description	Unit	To Be Filled By Bidder
9.1	Material		
9.2	Continuous current rating under site conditions		
9.3	Temperature rise over the design ambient of 50ºC		
10	Circuit breaker		
10.1	Manufacturer		
10.2	Type of circuit breaker		
10.3	Rated symmetrical breaking	kA	
10.4	Making current	kAp	
10.5	Rated S.C current withstand & duration	kA Sec	
10.6	One minute power frequency withstand voltage	kA	
10.7	Impulse withstand voltage	kVp	
10.8	Duty cycle		
10.9	Total break time	msec	
10.10	Make time	msec	
10.11	Switching over voltages generated and time to crest while switching off unloaded transformer	kVp /µsec	
10.12	Type of external switching over voltage limiting device provided		
10.13	Type of operating mechanism		
11	PTS		
11.1	Make		
11.2	Rated voltage factor		
i)	Continuous		
ii)	8 hours		
12	Earthing arrangement for		
12.1	Bus bar		
12.2	Cables		
13	Bus section isolator		
13.1	Type		
13.2	Rated current		
13.3	One min power frequency withstand voltage	kVrms	
13.4	1.2/50µsec impulse withstand voltage	KVp	
13.5	Minimum no. of auxiliary contacts		

C) 33 kV Switchgears for BFV, Surge Shaft, Chuplangchhu Intake, Tailrace Outfall and Dam Area

Sl. No.	Description	Unit	To Be Filled By Bidder
1	Manufacturer/s name		
2	Applicable standards		
3	Type of circuit breaker		

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Sl. No.	Description	Unit	To Be Filled By Bidder
4	Max. continuous voltage	kVrms	
4.1	Switchboard		
4.2	Breaker		
4.3	CT / VT		
5	Impulse withstand voltage / PF withstand voltage	kVp / kVrms	
5.1	Switchboard		
5.2	Breaker		
5.3	CT / VT		
6	SC current withstand capability (current / duration)	kA / sec	
6.1	Switchboard		
6.2	Breaker		
6.3	CT		
7	Momentary current withstand	kAp	
8	Degree of protection for switchboard		
8.1	Bus bar compartment		
8.2	Other compartment		
9	Bus bar		
9.1	Material		
9.2	Continuous current rating under site conditions		
9.3	Temperature rise over the design ambient of 50ºC		
10	Circuit breaker		
10.1	Manufacturer		
10.2	Type of circuit breaker		
10.3	Rated symmetrical breaking	kA	
10.4	Making current	kAp	
10.5	Rated S.C current withstand & duration	kA Sec	
10.6	One minute power frequency withstand voltage	kA	
10.7	Impulse withstand voltage	kVp	
10.8	Duty cycle		
10.9	Total break time	msec	
10.10	Make time	msec	
10.11	Switching over voltages generated and time to crest while switching off unloaded transformer	kVp /µsec	
10.12	Type of external switching over voltage limiting device provided		
10.13	Type of operating mechanism		
11	PTS		
11.1	Make		
11.2	Rated voltage factor		
1)	Continuous		

Sl. No.	Description	Unit	To Be Filled By Bidder
ii)	8 hours		
12	Earthing arrangement for		
12.1	Bus bar		
12.2	Cables		
13	Bus section isolator		
13.1	Type		
13.2	Rated current		
13.3	One min power frequency withstand voltage	kVrms	
13.4	1.2/50µsec impulse withstand voltage	KVp	
13.5	Minimum no. of auxiliary contacts		

2.22.2 Recommended Additional Spare Parts

List hereunder the spare parts which are recommended by the Contractor for purchase in addition to the mandatory spare parts as per Chapter-22 of Volume IV, Section 7. The purchase of any or all of the recommended spare parts will be at the option of KHPL. The prices for recommended additional spare parts for five (5) years shall be quoted separately in the format provided in the Price Schedule (Section F).

Item	Description	Make/Type	Quantity
1			
2			
3			
4			

* Use additional sheets if required

2.22.3 Information to be supplied together with the Bid

At least the information listed hereunder shall be given by the Bidder. The Bidder may submit additional documents /descriptions to describe special technical features of offered equipment / system:

i) Technical offer

ii) Dully filled Datasheet B

iii) Type test certificate of similar type of comparable rating.

iv) General Arrangement drawings of MV Switchgear

v) Vendor list for various components, fittings and accessories.

vi) Catalogues of MV Switchgear and its accessories.

vii) Transportation details

2.22.4 Lists of Tools & Instruments

List of tools and instruments shall be listed below in additional to the list provided by the employer.

Sl. No	Item/Description	Quantity offered
1	Assembly & erection tools	
2	Testing & Commissioning tools	
3	Testing and Commissioning instruments & devices	
4	Special tools & devices needed for routine maintenance purposes	

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2.22.5 Similar Installations (in last 20 years) by the Contactor

Sl. No	Description	Name of owner/utility	Quantity supplied	Year of supply/ commissioning



2.23 LV Switchgear

2.23.1 Guaranteed Technical Particulars

Sl. No.	Description	Unit	To Be Filled By Bidder
1	**General Particulars**		
1.1	Manufacturer's Name		
1.2	Manufacturer's type designation		
1.3	Applicable Standard		
1.4	Degree of Protection of the enclosure		
1.5	Overall dimensions of each switchgear cubicle (Length x Depth x Height)	mm	
1.6	Minimum space required in front and rear	mm	
1.7	Cubicle weight with circuit breaker	kg	
1.8	Dynamic Loading	kg	
1.9	One minute power frequency withstand voltage	kV rms	
1.10	1.2/50µS impulse withstand voltage	kV peak	
2	**Bus Bars**		
2.1	Material		
2.2	Bare/Insulated		
2.3	Number and size of 1 phase	mm x mm	
2.4	Minimum Clearance		
i)	Phase to phase	mm	
ii)	Phase to earth	mm	
2.5	Busbar Arrangement		
i)	Horizontal or vertical		
ii)	Phase segregation provided	Yes / No	
iii)	Voltage class of support insulators		
2.6	Current rating under reference ambient condition		
i)	Continuous		
ii)	One second		
iii)	Dynamic		
3	**Circuit Breakers**		
3.1	Manufacturer's type designation		
3.2	Applicable standard		

Sl. No.	Description	Unit	To Be Filled By Bidder
3.3	Duty cycle for the breaking capacity		
3.4	Total interrupting time measured from trip coil energisation	Cycle	
3.5	Total making time measured from closing coil energisation	Cycle	
3.6	Main Contacts		
i)	Type		
ii)	Material		
iii)	Thickness of Silver plating		
3.7	Arcing Contacts		
i)	Type		
ii)	Material		
iii)	Thickness of Silver plating		
3.8	Closing coil consumption at rated voltage	Watts	
3.9	Trip coil consumption at rated voltage	Watts	
3.10	Number of auxiliary contacts		
3.11	Spring charging motor		
i)	Rating	Watts	
ii)	Type	AC/DC	
iii)	Voltage	V	
iv)	Class of insulation		
4	**Current Transformers**		
4.1	Type (bar/wound)		
4.2	Applicable Standard		
4.3	Class of insulation		
4.4	Short time withstand capability		
i)	Short time current 1 sec.	kA rms	
ii)	Dynamic rating	kA Peak	
5	**Voltage Transformers**		
5.1	Type		
5.2	Applicable Standard		
5.3	Type of insulation		
5.4	Ratio		
5.5	Connections		
5.6	Rated output burden (1-phase)	VA	
5.7	Accuracy class		
5.8	H.V. Fuse Rating/Rupturing Duty	A / kA	
5.9	Rated Voltage Factor		
i)	Continuous		
ii)	Short time		
6	**Relays (Type & Make)**		
6.1	Inverse time over current relay		
6.2	Instantaneous over current relay		
6.3	Thermal overload relay		
6.4	Locked Rotor Protection Relay		

Sl. No.	Description	Unit	To Be Filled By Bidder
6.5	Earth Fault Relay		
6.6	Voltage operated, neutral - displacement relay		
6.7	Under voltage relay		
6.8	Earth leakage relay (with core balance CTs)		
6.9	Differential Relay		
6.10	Auxiliary relays		
6.11	Relays drawout type	Yes/No	
7	**Spares**		
7.1	List of recommended spares for normal maintenance for a period of 5 years furnished	Yes/No	
8	**Tests**		
8.1	Type tests certificates furnished with the bid	Yes/No	
9	**Drawings**		
9.1	List of drawings submitted along with bid		
10	Technical literature for the following are submitted with the bid		
10.1	Switchgear	Yes/No	
10.2	Circuit Breakers	Yes/No	
10.3	CTs & VTs	Yes/No	
10.4	Relays	Yes/No	

2.23.2 Recommended Additional Spare Parts

List hereunder the spare parts which are recommended by the Contractor for purchase in addition to the mandatory spare parts as per Chapter-23 of Volume IV, Section 7. The purchase of any or all of the recommended spare parts will be at the option of KHPL. The prices for recommended additional spare parts for five (5) years shall be quoted separately in the format provided in the Price Schedule (Section F).

Item	Description	Make/Type	Quantity
1			
2			
3			
4			

* Use additional sheets if required

2.23.3 Information to be supplied together with the Bid

At least the information listed hereunder shall be given by the Bidder. The Bidder may submit additional documents /descriptions to describe special technical features of offered equipment / system:

i) Technical offer
ii) Dully filled Datasheet B

iii) Type test certificate of similar type of comparable rating.
iv) General Arrangement drawings of LV Switchgear.
v) Vendor list for various components, fittings and accessories.
vi) Catalogues of LV Switchgear and its accessories.
vii) Transportation details.

2.23.4 Lists of Tools & Instruments

List of tools and instruments shall be listed below in additional to the list provided by the employer.

Sl. No	Item/Description	Quantity offered
1	Assembly & erection tools	
2	Testing & Commissioning tools	
3	Testing and Commissioning instruments & devices	
4	Special tools & devices needed for routine maintenance purposes	

2.23.5 Similar Installations (in last 20 years) by the Contactor

Sl. No	Description	Name of owner/utility	Quantity supplied	Year of supply/ commissioning

2.24 Auxiliary Transformer

2.24.1 Guaranteed Technical Particulars

(A) UAT

Sl. No.	Item	Unit	To Be Filled By Bidder
1	Manufacturer		
2	Type		Unit Auxiliary Transformer
3	Full load rating	kVA	
4	Number of Phases	One/ Three	
5	Rated no-load voltage		
5.1	(a) HV	kV	
5.2	(b) LV	kV	
6	Type of Cooling		
7	Winding connections		
7.1	HV		
7.2	LV		
7.3	Vector group		
8	Tapping on winding		
8.1	On load/off load tap links		
8.2	Total tapping range	%	
8.3	Tapping steps		
8.4	On HV/LV windings		
9	Windings		
9.1	Winding conductor material (HV/LV)		
9.2	Current density HV/LV	A/mm^2	
9.3	Type of insulation		
10	Maximum temperature rise of windings	^{0} C	
11	Cooling equipment power loss		
12	Magnetization current at rated voltage and frequency in percent of full load current	%	
13	Noise	db	
14	Weight		
14.1	Windings	Kg	
14.2	Core	Kg	
14.3	Total	Kg	
15	Efficiency at max winding temperature At full load, at UPF and 0.8PF Lag At 75% load, at UPF and 0.8PF Lag At 50% load, at UPF and 0.8PF Lag	%	
16	Maximum Flux Density		
16.1	At rated voltage	Wb/m^2	
16.2	At 110% of rated voltage	Wb/m^2	
17	Is transformer suitable for over fluxing conditions	Yes/No	
18	Enclosure		
18.1	Thickness of sheet metal	mm	

Sl. No.	Item	Unit	To Be Filled By Bidder
18.2	Rollers Type		
19	Whether special care is to be taken for electro-magnetic interference caused by the distribution transformers.	Yes/No	
20	SPARES		Recommended quantities and unit prices to be indicated by the BIDDER in his quotation
21	Over all Dimension of the Transformer (L x W X H) in mm	mm	
22	Dimension of Largest Package	mm	
23	Maximum Shipping Weight	Kgs	
24	Total Weight	Kgs	
25	Transformer losses: i) No load losses at rated voltage on principal tapping & at rated frequency ii) Load loss at rated current at principal tapping at 75 deg C iii) Auxiliary losses		

(B) SAT

Sl. No.	Item	Unit	To Be Filled By Bidder
1	Manufacturer		
2	Type		Station Auxiliary Transformer
3	Full load rating	kVA	
4	Number of Phases	One/ Three	
5	Rated no-load voltage		
5.1	(a) HV	kV	
5.2	(b) LV	kV	
6	Type of Cooling		
7	Winding connections		
7.1	HV		
7.2	LV		
7.3	Vector group		
8	Tapping on winding		
8.1	On load/off load tap links		
8.2	Total tapping range	%	
8.3	Tapping steps		
8.4	On HV/LV windings		
9	Windings		
9.1	Winding conductor material (HV/LV)		
9.2	Current density HV/LV	A/mm^2	
9.3	Type of insulation		
10	Maximum temperature rise of windings	^{0} C	

Sl. No.	Item	Unit	To Be Filled By Bidder
11	Cooling equipment power loss		
12	Magnetization current at rated voltage and frequency in percent of full load current	%	
13	Noise	db	
14	Weight		
14.1	Windings	Kg	
14.2	Core	Kg	
14.3	Total	Kg	
15	Efficiency at max winding temperature At full load, at UPF and 0.8PF Lag At 75% load, at UPF and 0.8PF Lag At 50% load, at UPF and 0.8PF Lag	%	
16	Maximum Flux Density		
16.1	At rated voltage	Wb/m^2	
16.2	At 110% of rated voltage	Wb/m^2	
17	Is transformer suitable for over fluxing conditions	Yes/No	
18	Enclosure		
18.1	Thickness of sheet metal	mm	
18.2	Rollers Type		
19	Whether special care is to be taken for electro-magnetic interference caused by the distribution transformers.	Yes/No	
20	SPARES		Recommended quantities and unit prices to be indicated by the BIDDER in his quotation
21	Over all Dimension of the Transformer (L x W X H) in mm	mm	
22	Dimension of Largest Package	mm	
23	Maximum Shipping Weight	Kgs	
24	Total Weight	Kgs	
25	Transformer losses: i) No load losses at rated voltage on principal tapping & at rated frequency ii) Load loss at rated current at principal tapping at 75 deg C iii) Auxiliary losses		

(C) Pothead Yard Auxiliary Transformer

Sl. No.	Item	Unit	To Be Filled By Bidder
1	Manufacturer		
2	Type		Pothead Yard Auxiliary Transformer
3	Full load rating	kVA	

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Sl. No.	Item	Unit	To Be Filled By Bidder
4	Number of Phases	One/ Three	
5	Rated no-load voltage		
5.1	(a) HV	kV	
5.2	(b) LV	kV	
6	Type of Cooling		
7	Winding connections		
7.1	HV		
7.2	LV		
7.3	Vector group		
8	Tapping on winding		
8.1	On load/off load tap links		
8.2	Total tapping range	%	
8.3	Tapping steps		
8.4	On HV/LV windings		
9	Windings		
9.1	Winding conductor material (HV/LV)		
9.2	Current density HV/LV	A/mm^2	
9.3	Type of insulation		
10	Maximum temperature rise of windings	^{0} C	
11	Cooling equipment power loss		
12	Magnetization current at rated voltage and frequency in percent of full load current	%	
13	Noise	db	
14	Weight		
14.1	Windings	Kg	
14.2	Core	Kg	
14.3	Total	Kg	
15	Efficiency at max winding temperature At full load, at UPF and 0.8PF Lag At 75% load, at UPF and 0.8PF Lag At 50% load, at UPF and 0.8PF Lag	%	
16	Maximum Flux Density		
16.1	At rated voltage	Wb/m^2	
16.2	At 110% of rated voltage	Wb/m^2	
17	Is transformer suitable for over fluxing conditions	Yes/No	
18	Enclosure		
18.1	Thickness of sheet metal	mm	
18.2	Rollers Type		
19	Whether special care is to be taken for electro-magnetic interference caused by the distribution transformers.	Yes/No	
20	SPARES		Recommended quantities and unit prices to be indicated by the BIDDER in his quotation

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Sl. No.	Item	Unit	To Be Filled By Bidder
21	Over all Dimension of the Transformer (L x W X H) in mm	mm	
22	Dimension of Largest Package	mm	
23	Maximum Shipping Weight	Kgs	
24	Total Weight	Kgs	
25	Transformer losses: i) No load losses at rated voltage on principal tapping & at rated frequency ii) Load loss at rated current at principal tapping at 75 deg C iii) Auxiliary losses		

(D) Excitation Transformer

Sl. No.	Item	Unit	To Be Filled By Bidder
1	Manufacturer		
2	Type		Excitation Transformer
3	Full load rating	kVA	
4	Number of Phases	One/ Three	
5	Rated no-load voltage		
5.1	(a) HV	kV	
5.2	(b) LV	kV	
6	Type of Cooling		
7	Winding connections		
7.1	HV		
7.2	LV		
7.3	Vector group		
8	Tapping on winding		
8.1	On load/off load tap links		
8.2	Total tapping range	%	
8.3	Tapping steps		
8.4	On HV/LV windings		
9	Windings		
9.1	Winding conductor material (HV/LV)		
9.2	Current density HV/LV	A/mm^2	
9.3	Type of insulation		
10	Maximum temperature rise of windings	^{0} C	
11	Cooling equipment power loss		
12	Magnetization current at rated voltage and frequency in percent of full load current	%	
13	Noise	db	
14	Weight		
14.1	Windings	Kg	
14.2	Core	Kg	

Sl. No.	Item	Unit	To Be Filled By Bidder
14.3	Total	Kg	
15	Efficiency at max winding temperature At full load, at UPF and 0.8PF Lag At 75% load, at UPF and 0.8PF Lag At 50% load, at UPF and 0.8PF Lag	%	
16	Maximum Flux Density		
16.1	At rated voltage	Wb/m^2	
16.2	At 110% of rated voltage	Wb/m^2	
17	Is transformer suitable for over fluxing conditions	Yes/No	
18	Enclosure		
18.1	Thickness of sheet metal	mm	
18.2	Rollers Type		
19	Whether special care is to be taken for electro-magnetic interference caused by the distribution transformers.	Yes/No	
20	SPARES		Recommended quantities and unit prices to be indicated by the BIDDER in his quotation
21	Over all Dimension of the Transformer (L x W X H) in mm	mm	
22	Dimension of Largest Package	mm	
23	Maximum Shipping Weight	Kgs	
24	Total Weight	Kgs	
25	Transformer losses: i) No load losses at rated voltage on principal tapping & at rated frequency ii) Load loss at rated current at principal tapping at 75 deg C iii) Auxiliary losses		

(E) 33kV Service Transformer

Sl. No.	Item	Unit	To Be Filled By Bidder
	Manufacturer		
2	Type		33kV Service Transformer
3	Full load rating	kVA	
4	Number of Phases	One/ Three	
5	Rated no-load voltage		
5.1	(a) HV	kV	
5.2	(b) LV	kV	
6	Type of Cooling		

Sl. No.	Item	Unit	To Be Filled By Bidder
7	Winding connections		
7.4	HV		
7.5	LV		
7.6	Vector group		
8	Tapping on winding		
8.5	On load/off load tap links		
8.6	Total tapping range	%	
8.7	Tapping steps		
8.8	On HV/LV windings		
9	Windings		
9.4	Winding conductor material (HV/LV)		
9.5	Current density HV/LV	A/mm^2	
9.6	Type of insulation		
10	Maximum temperature rise of windings	^{0} C	
11	Cooling equipment power loss		
12	Magnetization current at rated voltage and frequency in percent of full load current	%	
13	Noise	db	
14	Weight		
14.4	Windings	Kg	
14.5	Core	Kg	
14.6	Total	Kg	
15	Efficiency at max winding temperature At full load, at UPF and 0.8PF Lag At 75% load, at UPF and 0.8PF Lag At 50% load, at UPF and 0.8PF Lag	%	
16	Maximum Flux Density		
16.3	At rated voltage	Wb/m^2	
16.4	At 110% of rated voltage	Wb/m^2	
17	Is transformer suitable for over fluxing conditions	Yes/No	
18	Enclosure		
18.3	Thickness of sheet metal	mm	
18.4	Rollers Type		
19	Whether special care is to be taken for electro-magnetic interference caused by the distribution transformers.	Yes/No	
20	SPARES		Recommended quantities and unit prices to be indicated by the BIDDER in his quotation
21	Over all Dimension of the Transformer (L x W X H) in mm	mm	
22	Dimension of Largest Package	mm	
23	Maximum Shipping Weight	Kgs	

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Sl. No.	Item	Unit	To Be Filled By Bidder
24	Total Weight	Kgs	
25	Transformer losses: i) No load losses at rated voltage on principal tapping & at rated frequency ii) Load loss at rated current at principal tapping at 75 deg C iii) Auxiliary losses		

2.24.2 Recommended Additional Spare Parts

List hereunder the spare parts which are recommended by the Contractor for purchase in addition to the mandatory spare parts as per Chapter-24 of Volume IV, Section 7. The purchase of any or all of the recommended spare parts will be at the option of KHPL. The prices for recommended additional spare parts for five (5) years shall be quoted separately in the format provided in the Price Schedule (Section F).

Item	Description	Make/Type	Quantity
1			
2			
3			
4			

* Use additional sheets if required

2.24.3 Information to be supplied together with the Bid

At least the information listed hereunder shall be given by the Bidder. The Bidder may submit additional documents /descriptions to describe special technical features of offered equipment / system:

i) Technical offer
ii) Dully filled Datasheet B
iii) Type test certificate.
iv) General Arrangement drawing
v) Catalogues
vi) Vendor list
vii) Transportation details

2.24.4 Lists of Tools & Instruments

List of tools and instruments shall be listed below in additional to the list provided by the employer.

Sl. No	Item/Description	Quantity offered
1	Assembly & erection tools	
2	Testing & Commissioning tools	
3	Testing and Commissioning instruments & devices	
4	Special tools & devices needed for routine maintenance purposes	

2.24.5 Similar Installations (in last 20 years) by the Contactor

Sl. No	Description	Name of owner/utility	Quantity supplied	Year of supply/ commissioning

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2.25 Lighting System

2.25.1 Guaranteed Technical Particulars

Sl. No.	Description	Unit	To Be Filled By Bidder
1	Name of the manufacturer & type lighting fittings		
2	Applicable standard		
3	Nominal working voltage		
4	Maximum permissible supply voltage variation for satisfactory operation of :		
4.1	Fitting	± %	
4.2	Accessories	± %	
5	Power factor at nominal working voltage and frequency		
6	Lighting distribution boards and lighting panels		
7	Degree of protection provided for following applications :		
7.1	Indoor	± %	
7.2	Outdoor	± %	
8	Thickness of sheet steel	mm	
9	Lighting Wires		
9.1	Make		
9.2	Applicable standard		
9.3	Voltage grade		
9.4	Conductor material	Cu/AI	

2.25.2 Recommended Additional Spare Parts

List hereunder the spare parts which are recommended by the Contractor for purchase in addition to the mandatory spare parts as per Chapter-25 of Volume IV, Section 7. The purchase of any or all of the recommended spare parts will be at the option of KHPL. The prices for recommended additional spare parts for five (5) years shall be quoted separately in the format provided in the Price Schedule (Section F).

Item	Description	Make/Type	Quantity
1			
2			
3			
4			

* Use additional sheets if required

2.25.3 Information to be supplied together with the Bid

At least the information listed hereunder shall be given by the Bidder. The Bidder may submit additional documents /descriptions to describe special technical features of offered equipment / system:

i) Technical Data sheet.
ii) Descriptive and illustrative literature on the lighting fixtures
iii) Bill of quantity.
iv) Vendor list for various components, fittings and accessories.

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2.25.4 Lists of Tools & Instruments

List of tools and instruments shall be listed below in additional to the list provided by the employer.

Sl. No	Item/Description	Quantity offered
1	Assembly & erection tools	
2	Testing & Commissioning tools	
3	Testing and Commissioning instruments & devices	
4	Special tools & devices needed for routine maintenance purposes	

2.25.5 Similar Installations (in last 20 years) by the Contactor

Sl. No	Description	Name of owner/utility	Quantity supplied	Year of supply/ commissioning

2.26 Grounding and Lightning Protection System

2.26.1 Guaranteed Technical Particulars

Item No.	Parameter	Units	Contractor's Data
1	Expected total earthing impedance of earthing system	ohm	
2	Design short-circuit and ground fault currents, 1 s		
2.1	13.8 kV generator and bus duct system	kA_{rms}	
2.2	400 KV System	kA_{rms}	
2.3	420 kV GIS system	kA_{rms}	
2.4	13.8kV System	kA_{rms}	
2.5	11 KV System	kA_{rms}	
2.6	33kV System	kA_{rms}	
2.7	415 V low voltage system	kA_{rms}	
2.8	Fault clearing time	sec	
3	Type and Material of earthing conductors		
3.1	buried in ground	-	
3.2	embedded in concrete	-	
3.3	installed above ground/floor	-	
4	Minimum conductor size for underground network and riser	mm^2	

2.26.2 Material and size of Earthing conductor

Sl. No.	DESCRIPTION	Selected Conductor (Exposed To Air/In Ground)	To Be Filled By Bidder
1	Main Earth Grid	75x12 mm GI/MS Flat	
		Or Size of MS rod as per the fault current requirement (min 32mm dia MS rod)	
2	GIS Earth Grid and raisers connection	50X6 mm Cu Flat	
3	Pothead	75X12 mm GI Flat for current carrying parts	
		50X6 mm GI Flat for non-current carrying parts	
4	11kV System	65X10 mm GI Flat	
5	13.8kV System Switchgear	65X8 mm GI Flat	
6	415V LT Board	65X10 mm GI Flat	
7	415V Distribution Boards	50X6 mm GI Flat	
8	Control Panel & Control Desk	25X3 mm GI Flat	
9	Push Button Starter/Junction Box	8SWG GI Wire	
10	Columns, Structures, Cable trays and bus duct enclosures	50X6 mm GI Flat	
11	Crane, rails, rail tracks & other non-current carrying metal parts	25X6 mm GI Flat	
12	LV Motors		

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Sl. No.	DESCRIPTION	Selected Conductor (Exposed To Air/In Ground)	To Be Filled By Bidder
12.1	above 125kW	50X6 mm GI Flat	
12.2	25kW to 125kW	25X6 mm GI Flat	
12.3	1kW to 25kW	25X3 mm GI Flat	
13	GSUT NEUTRAL Grounding	75X12 mm Minimum 2xCu Flat	
14	Generator NGT Grounding	75X12 mm Minimum 2xCu Flat	
15	TRANSFORMER (SST, SAT, UAT) Neutral , 11kV DG Set Neutral Grounding	65X10 mm Cu Flat (2 Run)	
16	Pothead Yard Surge Arrester and CVT / VT Grounding	50X6 mm Cu Flat	
17	Auxiliary Transformer Neutral and 415V DG Neutral	75X12 mm GI Flat	
18	Auxiliary Transformer Neutral and 415V DG Neutral	75X12 mm GI Flat	

2.26.3 Recommended Additional Spare Parts

List hereunder the spare parts which are recommended by the Contractor for purchase in addition to the mandatory spare parts as per Chapter-26 of Volume IV, Section 7. The purchase of any or all of the recommended spare parts will be at the option of KHPL. The prices for recommended additional spare parts for five (5) years shall be quoted separately in the format provided in the Price Schedule (Section F).

Item	Description	Make/Type	Quantity
1			
2			
3			
4			

* Use additional sheets if required

2.26.4 Information to be supplied together with the Bid

At least the information listed hereunder shall be given by the Bidder. The Bidder may submit additional documents /descriptions to describe special technical features of offered equipment / system:

i) Technical offer
ii) Technical Data sheet.
iii) GA of Earth electrode
iv) Vendor list for various components, fittings and accessories



2.26.5 Lists of Tools & Instruments

List of tools and instruments shall be listed below in additional to the list provided by the employer.

Sl. No	Item/Description	Quantity offered
1	Assembly & erection tools	
2	Testing & Commissioning tools	
3	Testing and Commissioning instruments & devices	
4	Special tools & devices needed for routine maintenance purposes	

2.26.6 Similar Installations (in last 20 years) by the Contactor

Sl. No	Description	Name of owner/utility	Quantity supplied	Year of supply/ commissioning



2.27 Emergency Diesel Generator System

2.27.1 Guaranteed Technical Particulars

Sl. No.	Item	Unit	Bidder	
1	**Diesel Engine General Data**			
1.1	Designation		Diesel Generator	
1.2	Number offered			
1.3	Tag numbers			
1.4	Manufacturer's name, make, model			
i)	Number			
1.5	Standard rating at ISO conditions	kW	315	125
1.6	De-rating factors due to :			
i)	Harmonics	%		
ii)	Altitude	%		
iii)	Inlet air temperature	%		
iv)	Humidity	%		
v)	Cooling water temperature	%		
vi)	Overall derating factor (max 10%)	%	Total 6.1 To 6.5	
1.7	Continuous output at site conditions	kW		
1.8	Maximum engine rating at site			
i)	Conditions with 10% overload	kW		
1.9	Number of cylinders			
1.10	Arrangement of cylinders			
1.11	Direction of rotation as viewed from			
i)	Free end			
1.12	Operating speed	rpm		
1.13	Number of strokes			
1.14	Piston speed	M/sec		
1.15	Minimum acceptable lube oil			
i)	Temperature at start-up	°C		
1.16	Maximum period for which the engine			
i)	Can operate without cooling water	min		
ii)	Supply			
1.17	Foundation bolts and anti vibration		Whether Provided	
i)	Pads to be provided		Yes/No	
2	**Turbocharger**			
2.1	Manufacturer			
2.2	Speed	rpm		
3	**Fuel oil system**			
3.1	Day tank			
i)	Number of day tanks			
ii)	Capacity-each	Litres		
iii)	Material of construction			
iv)	Thickness of shell			
3.2	Hand operated fuel oil pump provided		Yes/No	
3.3	Filters			
i)	Type			
ii)	Number			

Sl. No.	Item	Unit	Bidder
4	**Lube oil system**		
4.1	Filters		
i)	Type		
ii)	Number		
iii)	Grade of lube oil to be used		
4.2	AC / DC motor driven standby pump, if any, to be included		Whether Included Yes / No
4.3	AC motor driven priming oil pump with clock timer		Whether Included Yes / No
5	**Engine Cooling System**		
5.1	Cooling water /make-up water		
i)	Quality acceptable		YES/NO
ii)	If no, indicate requirement		
5.2	Cooling water flow rate		
i)	Engine cooling circuit	LPM	
ii)	Lube oil cooler	LPM	
iii)	Turbocharger cooler	LPM	
iv)	Total 32.1 to 32.3	LPM	
5.3	Expansion tank		
i)	Capacity	Litres	
ii)	Material of construction		
iii)	Thickness	mm	
5.4	By-pass control valves to be		WHETHER INCLUDED
i)	Included		YES/NO
5.5	Temperature of cooling water		
ii)	At engine inlet	^{0}C	
iii)	At engine outlet	^{0}C	
6	**Air Intake And Exaust**		
5.1	Intake filter type		DRY / WET
5.2	Exhaust silencer type		Residential / industrial
5.3	Maximum back pressure	mmWC	
7	**Air Starting System**		
7.1	Air compressor		
i)	Ac motor driven air compressor		Whether included YES / NO
ii)	Diesel engine driven air compressor		Whether included YES / NO
7.2	Air receivers		
iii)	Number offered/tag numbers		/
iv)	Capacity of each air receiver	Litres	
7.3	Quantity of free air per start	m^3	
7.4	Starting air pressure	kg/cm^2	
8	**Stack**		
8.1	Flow rate of flue gases leaving DG	M^3/Hr	
8.2	Temperature of flue gas leaving		
i)	DG Set / Entering Stack	^{0}C	/

Sl. No.	Item	Unit	Bidder	
8.3	Density of flue gases at stack inlet	kg/M^3		
8.4	Stack diameter x height	M	x	
8.5	Number of flue gas openings			
8.6	Flue gas connection size	M	x	
8.7	Height of flue gas connection			
i)	Centre-Line Above Tfh Foundation Level	m		
9	**Heat exchanger**			
9.1	Type		Shell and tube / plate	
i)	Type of construction			
ii)	Shell side			
iii)	Flow rate of fluid circulated			
iv)	Inlet / outlet temperature	°C		
v)	Tube side			
vi)	Fluid circulated	cooling water		
vii)	Flow rate of fluid circulated	kg/Hr		
viii)	Inlet / outlet temperature	°C	/	/
9.2	Material specification			
i)	Shell/frame (for plate type)			
ii)	Tubes/plates (for plate type)			
iii)	Tube sheets/end plate (for plate type)			
iv)	Bolts/nuts			
v)	Gaskets			
9.3	Radiator			
i)	Material of construction			
ii)	Fan motor rating	kW		
10	**Generator Accessories**			
10.1	Manufacturer's name			
10.2	Design rating	kW		
10.3	Continuous output rating	kW		
i)	Nominal ISO rating	kW		
ii)	Maximum rating at site	kW		
iii)	Derated output under harmonic loading	kW		
10.4	Power factor			
10.5	Rated voltage	V	/	
10.6	Rated current / phase	Amps		
10.7	Speed	rpm		
10.8	Frequency	Hz		
10.9	Field current at rated output and voltage	Amps		
10.10	Insulation class			
i)	Stator			
ii)	Rotor			
10.11	Temperature rise above ambient of 50° (By thermometer)			
i)	Stator	°C		
ii)	Rotor	°C		
iii)	Cores	°C		

Sl. No.	Item	Unit	Bidder	
10.12	Moment of inertia of rotating mass in Diesel engine, generator, exciter etc.	kgM^2		
10.13	Efficiency			
i)	50% load/75% load /full load	%	/	
10.14	Largest motor allowed to start within 15% maximum allowable starting voltage dip	kW		
i)	With DOL starter/star delta starter		/	
10.15	KW rating of space heaters	kW		
10.16	Transient reactance			
i)	X'd	%		
ii)	X''d	%		
iii)	Degree Of Protection			
11	**Main Exciter**			
11.1	Rated voltage	V		
11.2	Rated current	Amps		
11.3	Ceiling voltage at zero load and			
i)	Rated speed	V		
11.4	Ceiling voltage at rated current and			
i)	Rated speed	V		
11.5	Excitation system response ratio			
11.6	Insulation class			
i)	Stator			
ii)	Rotor			
12	**Automatic Voltage Regulator**			
12.1	Type			
12.2	Burden of AVR on CTs and PTs			
i)	CTs	VA		
ii)	PTs	VA		
12.3	Dead Band, If Any			
12.4	Field Discharge Resistor	Ohms		
12.5	Type And Rating Of Field Breaker			
13	**Performance Guarantee**			
13.1	Continuous output at site conditions	kW		
13.2	10% overload for one(1) hour out of			
i)	A total of 12 consecutive hours of	kW		
ii)	Operation without over heating		+	
13.3	Fuel oil consumption at 50%, 75% and		50%	±
i)	Full load	gms/kWh	75%	±
			FL	
13.4	Lube oil consumption	gms/kWh		
13.5	Cooling water temperature at engine			
i)	Outlet	^0C	±	
13.6	Cooling water pressure drop	kg/cm^2	±	
13.7	Noise level	dB(A)	± AT	M
14	**Weight Schedule**			
14.1	Weight of engine and standard			

Sl. No.	Item	Unit	Bidder
14.2	Accessories excluding the weight of Flywheel	kg	
14.3	Weight of flywheel	kg	
14.4	Total shipping weight	kg	
i)	Weight of generator	kg	
ii)	Weight of control panel	kg	
iii)	Weight of single heaviest piece to be handled during :		
a)	Erection	kg	
b)	Maintenance	kg	
15	**Dimensions**		
15.1	Shipping Dimensions		
i)	ENGINE L X B X H	m	x x
ii)	GENERATOR L X B X H	m	x x
16	**MISCELLANEOUS**		
16.1	General arrangement drawing to be enclosed		Whether Enclosed Yes / No
16.2	P&i diagram to be enclosed		Whether Enclosed Yes / No
16.3	Total heat dissipation from dg set	kcal/Hr	
16.4	Ventilation requirements to be enclosed		Whether Enclosed Yes / No
16.5	Protection scheme to be enclosed		Whether Enclosed Yes / No
16.6	Suitability of operation for the load pattern to be confirmed		Yes / No

2.27.2 Recommended Additional Spare Parts

List hereunder the spare parts which are recommended by the Contractor for purchase in addition to the mandatory spare parts as per Chapter 27 of Volume-IV Section 7. The purchase of any or all of the recommended spare parts will be at the option of KHPL. The prices for recommended additional spare parts for five (5) years shall be quoted separately in the format provided in the Price Schedule (Section F).

Item	Description	Make/Type	Quantity
1			
2			
3			
4			

* Use additional sheets if required

2.27.3 Information to be supplied together with the Bid

At least the information listed hereunder shall be given by the Bidder. The Bidder may submit additional documents /descriptions to describe special technical features of offered equipment / system:

i) Technical offer

ii) Dully filled Datasheet B

iii) Type test certificate of similar type of DG set

iv) General Arrangement drawings for DG set

v) Catalogue of DG set and its major items

vi) Vendor list for various components, fittings and accessories.

vii) Transportation details

2.27.4 Lists of Tools & Instruments

List of tools and instruments shall be listed below in additional to the list provided by the employer.

Sl. No	Item/Description	Quantity offered
1	Assembly & erection tools	
2	Testing & Commissioning tools	
3	Testing and Commissioning instruments & devices	
4	Special tools & devices needed for routine maintenance purposes	

2.27.5 Similar Installations (in last 20 years) by the Contactor

Sl. No	Description	Name of owner/utility	Quantity supplied	Year of supply/ commissioning

2.28 Oil Handling and Purification System

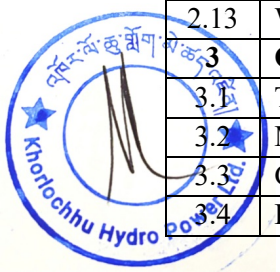
2.28.1 Guaranteed Technical Particulars

Item No.	Parameter	Units	Contractor's Data
1	**Oil pumps**		
1.1	Name of Manufacturer		
1.2	Type		
1.3	Capacity	m^3/hr	
1.4	Pressure	kg/cm^2	
2	**Oil purification unit**		
2.1	Name of manufacturer		
2.2	Type		
2.3	Capacity	m^3/hr	
2.4	Pressure	kg/cm^2	
2.5	Content of mechanical impurities after one cycle of leaning	ppm	
2.6	Content of water in oil after one cycle of cleaning (ppm)	ppm	
2.7	Thinness of filtration (micron) after one cycle of cleaning	micron	
3	**Barrel pump**		
3.1	Name of manufacturer		
3.2	Type		
3.3	Capacity	Litres/sec	

2.28.2 Information Data

Item No.	Parameter	Units	Contractor's Data
1	**Oil Tanks**		
1.1	Clean oil capacity		
i)	Gross	m^3	
ii)	Net	m^3	
1.2	Dirty oil tank capacity (m^3)		
i)	Gross	m^3	
ii)	Net	m^3	
1.3	Diameter	mm	
1.4	Height	mm	
1.5	Weight	kg	
1.6	Material of construction, thickness & strength of plates		
1.7	Name of manufacturer		
1.8	Type of level indicator		
1.9	Manholes		
i)	Number		
ii)	Size		
iii)	Location		
1.10	Vent pipe size		
1.11	Overflow line size		
1.12	Oil Inlet		

Item No.	Parameter	Units	Contractor's Data
i)	Size		
ii)	Type & size of valve provided		
1.13	Oil outlet		
i)	Size		
ii)	Type & size of valve provided		
1.14	Oil d		
i)	Size		
ii)	Type & size of valve provided		
1.15	Ladder (Integral with tank or detachable type)		
1.16	Types of paint used		
i)	Inside surface		
ii)	Outside surface		
1.17	Test pressure		
i)	Filling material (water/oil/air)		
ii)	Pressure to be applied		
iii)	Duration of application of maximum test pressure		
1.18	Total weight		
2	**Oil Pump**		
2.1	Type		
2.2	Manufacturer		
2.3	Capacity	m^3/hr	
2.4	Maximum suction lift		
2.5	Discharge pressure	kg/cm^2	
2.6	Motor		
i)	Power rating		
ii)	Voltage/frequency		
iii)	Class of insulation		
iv)	Full load current		
v)	Rpm at rated output		
vi)	Temperature rise		
2.7	Bearing temperature rise in continuous operation		
2.8	Material for gears		
2.9	Size of suction inlet		
2.10	Size of outlet		
2.11	Relief valve		
i)	Size and type		
ii)	Pressure switch at which relief valve is set		
2.12	Overall dimension (L x W x H)		
2.13	Weight		
3	**Oil Purifier**		
3.1	Type		
3.2	Manufacturer		
3.3	Capacity	m^3/hr	
3.4	Pressure	kg/cm^2	



Item No.	Parameter	Units	Contractor's Data
3.5	Purifier Pumps		
i)	No. & type		
ii)	Maximum suction life		
iii)	Discharge pressure		
iv)	Bearing temperature rise in continuous operation		
v)	Material of gears		
vi)	Size of suction inlet		
vii)	Size of outlet		
viii)	Relief valve size, type & pressure		
ix)	Make & type of flexible coupling		
3.6	Contents of impurities after one cycle of cleaning		
i)	Mechanical impurities	ppm	
ii)	Water impurities	ppm	
3.7	Heaters		
i)	Capacity	Watts	
ii)	Voltage	V	
iii)	Recommended temperature for purification of oil	^{o}C	
iv)	Range of temperature control by control switches	^{0}C	
v)	Whether interlocking scheme for switching off of heater is included		
3.8	Sample valves		
i)	Number		
ii)	Size		
3.9	Details of filters & thinness of filtration	Microns	
3.10	Motor		
i)	Power rating		
ii)	Voltage, frequency		
iii)	Class of insulation		
iv)	Full load current		
v)	Rpm at rated output		
vi)	Temperature rise		
3.11	Flow meter details		
3.12	Details of provision provided to prevent operation of centrifuge unless feed pump & discharge pump are operating		
3.13	Details of bypass/relief valve		
3.14	Details & safety devices/switches provided		
3.15	Overall dimension (L x W x H)		
3.16	Weight		
3.17	Size, make & type of flexible coupling & hose		
4	**Portable oil barrel pump**		
4.1	Type		
4.2	Manufacturer		

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Item No.	Parameter	Units	Contractor's Data
4.3	Capacity		
4.4	Discharge pressure	kg/cm^2	
4.5	Motor		
i)	Power rating		
ii)	Voltage, frequency		
iii)	Class of insulation		
iv)	Full load current		
v)	Rpm at rated output		
vi)	Temperature rise		
4.6	Dimension (L x W x H)		
4.7	Weight		
5	**Hose and hose coupling**		
5.1	Type and material		
5.2	Numbers provided & Size (dia x length of each)		
5.3	Whether oil resistant		
5.4	Type and details of coupling		
6	Piping, valves and other fittings, type sizes, IS to which they conform and other relevant details		
7	Any other details not included		

2.28.3 Recommended Additional Spare Parts

List hereunder the spare parts which are recommended by the Contractor for purchase in addition to the mandatory spare parts as per Chapter-28 of Volume IV, Section 7. The purchase of any or all of the recommended spare parts will be at the option of KHPL. The prices for recommended additional spare parts for five (5) years shall be quoted separately in the format provided in the Price Schedule (Volume 3).

Item	Description	Make/Type	Quantity
1			
2			
3			
4			

* Use additional sheets if required

2.28.4 Information to be supplied together with the Bid

At least the information listed hereunder shall be given by the Bidder. The Bidder may submit additional documents /descriptions to describe special technical features of offered equipment / system:

i. Pamphlets of each of the proposed oil purifying systems with main characteristics.

ii. Pamphlets of transformer evacuation system with main characteristics.

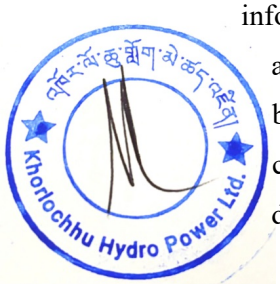
iii. Pamphlets of the proposed vacuum pump and oil transfer pump giving the following information

a. Pump flow characteristics

b. Cross section of pump with motor

c. Description of mechanical sealing system

d. Description of starter and starter panel.



e. Major dimensions of the pump-motor set and criteria of selection

2.28.5 Lists of Tools & Instruments

List of tools and instruments in accordance to the clause 28.15 of PTS Chapter-28 under Section-7 of Volume-4 shall be listed below in additional to the list provided by the employer.

Sl. No	Item/Description	Quantity offered
1	Assembly & erection tools	
2	Testing & Commissioning tools	
3	Testing and Commissioning instruments & devices	
4	Special tools & devices needed for routine maintenance purposes	

2.28.6 Similar Installations (in last 20 years) by the Contactor

Sl. No	Description	Name of owner/utility	Quantity supplied	Year of supply/ commissioning

2.29 Workshop Equipment

2.29.1 Guaranteed Technical Particulars

Sl. No.	Item	Unit	Requirement
1	**Mechanical Workshop Equipment**		
1.1	**Engine Lathe**		
i)	**Capacity**		
ii)	Quantity	No	
iii)	Centre distance	mm	
iv)	Swing over bed	mm	
1.2	**Column type drilling machine**		
i)	Quantity	No	
ii)	Working radius	mm	
iii)	Capacity	mm(in steel)	
iv)	Spindle travel	mm	
v)	Variable speed		
1.3	**Power Hacksaw**		
i)	Quantity	No	
ii)	Sawing Capacity	mm dia	
iii)	Two Speed Operation		
1.4	**Pedestal Tool Grinding Machine**		
i)	Quantity	No	
ii)	No of grinding wheels	Nos	
iii)	Dia of grinding wheel	mm	
1.5	**Universal Knee type milling machine**		
i)	Quantity	No	
1.6	**Single Pulley Shaping machine**		
i)	Quantity	No	
ii)	Stroke	mm	
1.7	**Toggle action shears** (Cutting 6 mm flat steel and 13 mm dia steel bar)		
i)	Quantity	No	
ii)	Knife length	mm	
1.8	**Gas Welding Equipment with gas bottle tray**		
i)	Quantity	No	
1.9	**Arc welding machine**		
i)	Quantity	No	
ii)	Electrode Dia (Max)	mm	
iii)	Accessories		
1.10	**Portable Drilling machine**		
i)	Quantity	No	
1.11	**Basic Tools**		
i)	Quantity	No	
1.12	**Portable electric grinder**		
i)	Quantity	Nos.	
1.13	**Tool Trolley with basic tool kit**		
i)	Quantity	No	
1.14	**Hydraulic Jack**		
i)	Quantity	Nos.	

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Sl. No.	Item	Unit	Requirement
ii)	Capacity	KN	
iii)	Quantity	Nos.	
iv)	Capacity	KN	
1.15	**Tackling Block**		
i)	Quantity	Nos.	
ii)	Capacity	KN	
1.16	**Tool Cabinet**		
i)	Quantity	No	
1.17	**Work Bench**		
i)	Quantity	No	
1.18	**Marking Plate**		
i)	Quantity	No	
1.19	**Levelling Plate**		
i)	Quantity	No	
ii)	Portable Toolboxes with basic tool kit	No	
2	**Instrumentation Lab Equipment**		
2.1	**Portable Digital Multimeter (4 ½ Digit)**		
i)	Quantity		
ii)	Make & Model No		
iii)	Ranges & Accuracy		
iv)	Features		-
v)	Power Supply		
vi)	Accessories		
2.2	**Test Manometer**		
i)	Quantity		
ii)	Make & Model No		
iii)	Range		
iv)	Scale		
v)	Material of Construction		
vi)	Features		
vii)	Accuracy		
viii)	End Connection		
ix)	Accessories		-
2.3	**Master Pressure Gauge**		
i)	Quantity		
ii)	Make & Model No		
iii)	Range		
iv)	Dial Size		
v)	Material		
vi)	Features		
vii)	Accuracy		
viii)	End Connection		
ix)	Pointer		
2.4	**Integrated Calibrator –Electronic & Pneumatic Instruments (Portable)**		
i)	Quantity		

Sl. No.	Item	Unit	Requirement
ii)	Make & Model No		
iii)	Range		
iv)	Display		
v)	Features		
vi)	Accuracy		
vii)	Accessories		
2.5	**Precision Set Thermometers (Mercury In Glass)**		
i)	Quantity		
ii)	Make & Model No		
iii)	Ranges		
iv)	Accessories		
2.6	Temperature Calibrator (Portable)		
i)	Quantity		
ii)	Type		
iii)	Features		
iv)	Ranges, resolution ,accuracy & stability		
v)	Display		
vi)	Accessories		
2.7	**Barometer**		
i)	Quantity		
ii)	Make & Model No		
iii)	Range		
iv)	Accuracy		
2.8	**Wet & Dry Bulb Hygrometer**		
i)	Quantity		
ii)	Make & Model No		
iii)	Range		
iv)	Features		
v)	Accuracy		
vi)	Resolution		
2.9	**Ultrasonic Flow meter (Portable)**		
i)	Quantity		
ii)	Make & Model No		
iii)	Type		
iv)	Range		
v)	Pipe size in mm		
vi)	Operating temperature		
vii)	Output		
viii)	Display		
2.10	**Test RTD**		
i)	Quantity		
ii)	Make & Model No		
iii)	Range		
iv)	Type		
v)	Insulation resistance		
vi)	Sheat Material		

Sl. No.	Item	Unit	Requirement
vii)	Sheat dimesnsions		
viii)	Others		
ix)	Accuracy:		
2.11	**mA & mV Calibrator (Portable)**		
i)	Quantity		
ii)	Make & Model No:		
iii)	Accuracy		
iv)	Range		
v)	Features		
vi)	Display		
vii)	Accessories		-
2.12	**Multifunction Calibrator**		
i)	Quantity		
ii)	Make & Model No		
iii)	Type		
iv)	Features		-
v)	Display		
vi)	Power supply		
vii)	Accessories		-
2.13	**High Resolution Timer/Count**		
i)	Quantity		
ii)	Make & Model No		
iii)	Features		
iv)	Range		
v)	Period		
vi)	Power supply		
2.14	**DC Regulated Power Supply**		
i)	Quantity		
ii)	Make & Model No		
iii)	Output DC voltage		
iv)	Output current		
v)	Protection		
vi)	Regulation		
vii)	Features		-
2.15	**Adjustable AC Power supply**		
i)	Quantity		
ii)	Make & Model No		
iii)	Type		-
iv)	Maximum output current		
v)	Output voltage		
vi)	Power supply		
2.16	**Digital Tong Tester**		
i)	Quantity		
ii)	Make & Model No		
iii)	Features		-
iv)	Range & Accuracy		
v)	Accessories		

Sl. No.	Item	Unit	Requirement
2.17	**Single Phase Auto Transformer**		
i)	Quantity		
ii)	Make & Model No		
iii)	Type		
iv)	Rated current		
v)	Maximum output current		
vi)	Power supply		
vii)	Output voltage		
2.18	**Insulation Tester (Megger)**		
i)	Quantity		
ii)	Make & Model No		
iii)	Range		
iv)	Display		
v)	Accessories		
2.19	**Sound Level Monitor**		
i)	Quantity		
ii)	Make & Model No		
iii)	Range		
iv)	Accuracy		
v)	Features		-
vi)	Frequency range		
vii)	Display		
viii)	Accessories		
2.20	**AC Power Meter**		
i)	Quantity		
ii)	Make & Model No		
iii)	Range		
iv)	Features		-
v)	Display		
vi)	Accessories		-
2.21	**Digital Tachometer**		
i)	Quantity		
ii)	Make & Model No		*
iii)	Type		
iv)	Range		-
v)	Features		
vi)	Accuracy		
vii)	Resolution		
viii)	Distance in non-contact mode		
ix)	Display		
x)	Power		
xi)	Accessories		-
2.22	**Potentiometer/ Rheostat**		
i)	Quantity		
ii)	Make & Model No		
iii)	Type		
iv)	Range		

Sl. No.	Item	Unit	Requirement
v)	Features		-
2.23	**Digital Stopwatch**		
i)	Quantity		
ii)	Make & Model No		
iii)	Modes		
iv)	Accuracy		
v)	Resolution		
vi)	Display Range		
vii)	Power		
viii)	Accessories		
2.24	**Furniture**		
	Required furniture consisting of table, desk, chairs, almirah, rack etc. shall be provided to set up laboratory. Same shall be completely erected by bidder. Furniture shall include but not limited to the following:		
i)	Worktable		
ii)	Desk		
iii)	Chairs		
iv)	Almirah		
v)	Instruments Shelf (Slotted angle rack)		

2.29.2 Recommended Additional Spare Parts

List hereunder the spare parts which are recommended by the Contractor for purchase in addition to the mandatory spare parts as per Chapter-29 of Volume IV, Section 7. The purchase of any or all of the recommended spare parts will be at the option of KHPL. The prices for recommended additional spare parts for five (5) years shall be quoted separately in the format provided in the Price Schedule (Volume 3).

Item	Description	Make/Type	Quantity
1			
2			
3			
4			

* Use additional sheets if required

2.29.3 Information to be supplied together with the Bid

At least the information listed hereunder shall be given by the Bidder. The Bidder may submit additional documents /descriptions to describe special technical features of offered equipment / system:

i) Technical offer

ii) Dully filled Datasheet

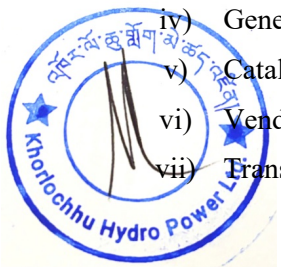
iii) Type test certificate of similar type of equipment

iv) General Arrangement drawings equipment

v) Catalogue of Equipment

vi) Vendor list for various components, fittings and accessories.

vii) Transportation details



2.29.4 Similar Installations (in last 20 years) by the Contactor

Sl. No	Description	Name of owner/utility	Quantity supplied	Year of supply/ commissioning



2.30 Fibre Optic Communication System

2.30.1 Guaranteed Technical Particulars

Sl. No	Description	Unit	Parameters
1	**General**		
1.1	Type of multiplexer		
1.2	Complying to ITU-T rec.		
1.3	Transmission Capacity	Gbit/s Mbit/s Mbit/s	
1.4	Access capacity on 64kbit/s	Channels	
1.5	Access capacity on 2Mbit/s	Channels	
1.6	Redundant central processor		
1.7	Digital cross connect function		
1.8	PDH cross connect capacity		
1.9	SDH cross connect capacity, high order		
1.10	SDH cross connect capacity, low order		
1.11	Equipment used in substation environment		
1.12	The equipment is KEMA type tested		
2	**Tele-protection Interface**		
2.1	Integrated distance tele protection interface		
2.2	Integrated IEC 61850 GOOSE based protection interface		
2.3	Integrated optical tele protection interface		
2.4	Addressing of protection commands		
2.5	Loop test for measuring delay time		
2.6	1+1 switch-over less than 10ms		
3	**Transport Level: Interfaces**		
3.1	Optical STM-16 interface supported		
3.2	Optical STM-4 interface supported		
3.3	Optical STM-1 interface supported		
3.4	SDH based on SFP technology		
3.5	Electrical SDH interface		
3.6	HDB3, 2Mbit/s interfaces per module		
3.7	Complying to ITU-T rec.		
3.8	Optical 10GE interface supported		
3.9	Optical 10GE interface		
3.10	Optical / Electrical 1GbE interface		
3.11	Switching capacity of Ethernet Switching Matrix		
3.12	MPLS-TP LSP per node	Amount	
3.13	OAM frame generation with 3.3 ms speed	Amount	
3.14	OAM frame generation with 50 ms speed	Amount	
3.15	1+1 bidirectional, symmetrical LSP protection		
3.16	1:1 bidirectional, symmetrical LSP protection		
3.17	Support of Synchronous Ethernet		
3.18	Support of IEEE1588 v2 transparent clock		
3.19	Support of time of day information using IEEE 1588 v2		

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Sl. No	Description	Unit	Parameters
3.20	Accuracy of time of day information per node	us	
3.21	Number of VLANs supported		
3.22	MAC address table size		
3.23	Number of ports in link aggregation group		
4	**DSL Interface**		
4.1	DSL type / line code		
4.2	2Mbit/s: Number of copper wires		
	USER INTERFACES		
5	**Voice Module For Trunk Lines**		
5.1	1+1 path protection, individually programmable		
5.2	Analogue, 4wire with E&M: Input level Output level	dBr	
5.3	Analogue, 2wire with E&M: Input level Output level	dBr	
5.4	Digital, 2Mbit/s CAS or PRI		
5.5	Number of interfaces per module		
6	**Voice Interfaces For Remote Subscriber**		
6.1	2wire, subscriber side	dBr	
6.2	Minimum number of subscribers per module		
6.3	2wire, PABX side	dBr	
6.4	Minimum number of PABX interfaces per module		
7	**Integrated Tele-protection – Interface For Commands**		
7.1	Number of independent commands per module		
7.2	Transmission time max.	ms	
7.3	Protection voltage	Max VDC	
7.4	1 + 1 path protection		
8	**Integrated Tele-protection – Interface For IEC61850 Goose Based Protection**		
8.1	PRP support		
8.2	Integration in IEC 61850 substation configuration file		
8.3	Capability for wire speed GOOSE signal translation		
8.4	Possibility to filter specific GOOSE messages and transmit the same to the remote end		
8.5	Trip counters for GOOSE signals		
8.6	Authentication of signals to detect data modification in WAN and replay of data		
8.7	Back to back latency of IEC 61850 GOOSE based protection interface data channels		
8.8	Number of interfaces per module		
8.9	IRIG-B outputs		
8.10	SNTP client and server functionality		
8.11	Status supervision		
9	**Interface(S) For Differential Protection**		
9.1	Optical interface IEC 60870-5-1	kbit/s	
9.2	Optical interface C37.94	Mbit/s	
9.3	Payload for protection relay	kbit/s	
9.4	Symmetrical Switching		

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Sl. No	Description	Unit	Parameters
10	**Data Module**		
10.1	V.24/V.28 (RS-232)		
10.2	V.11/X.24 (RS-422)		
10.3	V.35		
10.4	Integrated Ethernet port available on DATA Interface		
10.5	SW-programmable board available to assign different types of data interface to each port.		
10.6	Functions available for individual configuration: 1+1 path protection point-multipoint performance monitoring available for all data interface		
11	**Ethernet Module**		
11.1	**Ethernet A** 10/100/1000BaseT 1000Base LX/SX L2 switching function EoS WAN capacity ogical WAN ports GFP (acc. ITU-T G.7041) VCAT (acc. ITU-T G.707) LCAS (acc. ITU-T G.7042) xSTP	Mbit/s	
11.2	**Ethernet B** 10/100BaseT L3 Routing function Routing protocols WAN capacity WAN ports WAN protocol		
11.3	**Ethernet C** FE/GbE optical/electrical i/f Virtual routing (VRF/VPRN) Wire speed forwarding OSPFv2 (RFC 2328) OSPF auth. (Simple/ MD5) VRRPv3 (RFC 5798) basic FW (ACL rules/ DoS prot.) VLAN based rate limiting L3 HW supported QoS (DSCP) 1:1 HW protection (EQP) VLAN interfaces per module VRRP instances per module VRRP link tracking per module 1:1 NAT support		
11.4	**Ethernet D** Power over Ethernet	ports	
12	**Integrated Alarm Gathering Module**		
12.1	Number of external alarms per module		
12.2	Auxiliary power supply for ext. contacts		
13	**Configuration Tool**		
13.1	Type/Name of configuration tool		

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Sl. No	Description	Unit	Parameters
13.2	For local / remote operation		
13.3	Data communication network (DCN)		
13.4	Integrated Management of Tele protection Command module		
14	**Network Management System**		
14.1	Type/Name of configuration tool		
14.2	For fault / configuration management		
14.3	Data communication network (DCN)		
14.4	Management of integrated Tele Protection Command Module		
15	**Ambient Conditions**		
15.1	Storage: ETS 300 019-1-1, class 1.2	°C/ % hum	
15.2	Transport: ETS 300 019-1-2, class 2.2	°C/ % hum	
15.3	Operation: ETS 300 019-1-3, class 3.1E	°C/ % hum	
15.4	Operation in fan less configuration	°C/ % hum	
16	**Power Supply**		
16.1	Operation	VDC	
16.2	Dual power feeding		

2.30.2 Guaranteed Technical Particulars of 96 fibers Under-ground armored cable:

Sl. No.	Description	Parameters
1	Name of MANUFACTURER	
2	Country of manufacture	
3	Standard according to which cable is manufactured	
4	Kind of cable Duct/Direct burial / suitable for both	
5	Length of delivery (drum size) (M)	
6	Outer diameter of cable drum (M)	
7	Width of cable drum (M)	
8	Weight per kilometre of cable (Kg/Km)	
9	Maximum bending radius of cable	
10	Maximum tensile strength	
10.1	Long term (N)	
10.2	Short term (N)	
11	Maximum pressure strength (between parallel plates)	
11.1	Long term (N/Cm)	
11.2	Short term (N/Cm)	
12	Minimum bending radius	
12.1	Under normal conditions (mm)	
12.2	Under nominal tensile strength (mm)	
13	Maximum permissible tensile force for laying (N)	
14	Proof tension (kg)	
15	Compression Strength (Kg/Sq.Cm)	

16	Ambient temperature range (Deg. C)	
17	Overall diameter of cable (mm)	
18	Construction	Tight buffer / Loose buffer
19	Cable attenuation (dB/Km)	
20	Maximum fibre attenuation per kilometer at nominated wave lengths (dB/km) for temperature range ….. Deg. C to …..Deg. C)	
21	Optical fibre material	
22	Cladding material	
23	Manufacturing method	
24	Diameter of core (mm)	
25	Mode field diameter (mm)	
26	Coating material	
27	Core / Clad concentricity (%)	
27.1	Cladding non-circularity (%)	
27.2	Core non-circularity (%)	
28	Cladding activity	
29	Diameter over-coating	
29.1	First coat (mm)	
29.2	Second coat (mm)	
30	Buffer tube material	
31	Wall thickness of buffer tube (mm)	
32	Overall buffer tube diameter (mm)	
33	Buffer filling compound	
34	Dummy elements included (Yes/No)	
35	Material Type of Inner sheath and Thickness	
36	Material Type of outer sheath and Thickness	
37	Material Type of Rip Cord	
38	Thickness of ECCS armouring tape.	
39	Nature of dummy element	
40	Tensile strength of reinforcing material	
40.1	Material used as additive to PE/PVC serving.	
40.2	Toxic to humans (Yes/No)	
41	Maximum dispersion per kilometer (ps/nm/Km)	
41.1	Maximum numerical aperture at nominated wave lengths.	
41.2	Band width of optical fibre	

2.30.3 Recommended Additional Spare Parts

List hereunder the spare parts which are recommended by the Contractor for purchase in addition to the mandatory spare parts as per Chapter 32 of Volume IV. The purchase of any or all of the recommended spare parts will be at the option of KHPL. The prices for

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recommended additional spare parts for five (5) years shall be quoted separately in the format provided in the Price Schedule (Section F).

Item	Description	Make/Type	Quantity
1			
2			
3			
4			

* Use additional sheets if required

2.30.4 Information to be supplied together with the Bid

At least the information listed hereunder shall be given by the Bidder. The Bidder may submit additional documents /descriptions to describe special technical features of offered equipment / system:

i) Technical offer
ii) Test certificates of all tests as per relevant standards.
iii) Vendor list for all Major items
iv) Technical Datasheets, Literatures.
v) General arrangement showing main dimensions, mounting arrangements, terminals, etc.
vi) Schematic drawings
vii) List of Products Approvals

2.30.5 Lists of Tools & Instruments

List of tools and instruments in accordance to the clause 32.59 of PTS Chapter-32 under Section-7 of Volume-4 shall be listed below in additional to the list provided by the employer.

Sl. No	Item/Description	Quantity offered
1	Assembly & erection tools	
2	Testing & Commissioning tools	
3	Testing and Commissioning instruments & devices	
4	Special tools & devices needed for routine maintenance purposes	

2.30.6 Similar Installations (in last 20 years) by the Contactor

Sl. No	Description	Name of owner/utility	Quantity supplied	Year of supply/ commissioning



2.31 132kV Feeder Bay at Korlung Substation

2.31.1 Guaranteed Technical Particulars

Sl. No.	Description	Units	To Be Filled By Bidder
1	**132 kV Switchyard**		
1.1	Nominal voltage	kV	
1.2	Highest System voltage	kV	
1.3	Frequency	Hz	
1.4	Short circuit current	kA (rms)	
1.5	Making current	kA (Peak)	
1.6	Impulse withstand voltage	kV (Peak)	
1.7	One minute power frequency withstand voltage	kV (rms)	
1.8	Switching impulse withstand	kV (Peak)	
1.9	Reference ambient temperature	°C	
1.10	Creepage distance	mm	
1.11	Minimum Clearances		
i)	Phase to phase (min)	mm	
ii)	Phase to earth (min)	mm	
iii)	Sectional clearance	mm	
iv)	Ground clearance	mm	
1.12	Corona extinction voltage	kV (rms)	
2	**Isolators**		
2.1	Application		
2.2	Quantity		
i)	With earth switch	Nos	
ii)	Without earth switch	Nos	
2.3	Type		
2.4	Execution of poles		
2.5	Rated current	A	
2.6	Short circuit withstand current and duration	kA (rms) Sec	
2.7	Making current	kA (Peak)	
i)	Breaking capacity of line charging current	A	
ii)	Breaking capacity of magnetising current	A	
2.8	Short circuit making current of earthing switch	kA (Peak)	
2.9	Material of main contact		
2.10	Whether contacts are to be silver faced		
2.11	Operating mechanism		
i)	Operating device (motor / manual)		
ii)	Main disconnector		
iii)	Earth switch		
2.12	Emergency operation	1.0	
i)	Main disconnector		
ii)	Earth switch		
2.13	Support insulators		
i)	Type of insulator (Pedestal / Solid / Polycone etc.)		
ii)	Nominal creepage distance	mm	

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Sl. No.	Description	Units	To Be Filled By Bidder
2.14	**Minimum strength**		
i)	Torsoinal	Nm	
ii)	Minimum cantilever strength	kgs	
2.15	**Miscellaneous**		
i)	No. of NO & NC aux. Contacts for purchaser's use (main and earth switch)	Nos	
ii)	Pole discrepancy circuit required	Yes / No	
iii)	Purchaser's earthing conductor (material & size)	mm x mm	
iv)	Mounting structure included in vendor's scope of supply	Yes / No	
v)	Phase to phase spacing of poles	mm	
vi)	Height of connection/bus above ground level	mm	
2.16	Clamps and connectors		
i)	By purchaser/vendor		
ii)	Take off (Horz, Vert, etc)		
iii)	Conductor size and material		
2.17	Auxiliary supply		
i)	Electrical		
ii)	Type of interlock		
2.18	Environment : salty / dusty / normal/ corrosive / polluted		
2.19	Wind pressure	kg/Sq.m	
2.20	Coefficient of seismic acceleration		
2.21	Altitude above M.S.L.	Mtr	
2.22	List of type tests to be carried out		
2.23	Spares		
i)	Support insulator column		
ii)	Operating rod insulator		
iii)	Drive motor		
iv)	Motor contactor of each type		
v)	Fuses of each rating		
vi)	Spring		
3	**Lightning Arrestors**		
3.1	Quantity		
3.2	Installation		
3.3	System voltage		
i)	Nominal	kV	
ii)	Highest	kV	
3.4	System Earthing		
3.5	Type of arrester		
3.6	Short Circuit Current at Arrester Location	kA	
3.7	Maximum duration of earth fault	Sec	
3.8	Co-efficient of earthing		
3.9	Temperature limits		
3.10	Seismic requirement		

Sl. No.	Description	Units	To Be Filled By Bidder
3.11	Wind velocity		
3.12	Variation in frequency		
3.13	Rated values		
i)	Rated arrester voltage / maximum continuous operating voltage	kV	
ii)	Discharge class		
iii)	Maximum residual voltage at nominal discharge current		
iv)	Pressure relief class (short circuit capability)		
v)	Long duration current Impulse withstand		
	a) Discharge class		
	b) Peak current & virtual duration of peak	A/μs	
	c) High current impulse	kA (Peak)	
3.14	Gapless arrester		
i)	Continuous operating voltage	kV	
ii)	Residual voltage corresponding to		
	a) Steep current impulse	kV (Peak)	
	b) Switching current impulse	kV (Peak)	
3.15	Arrestor Housing		
i)	Material of housing		
ii)	Withstand Test Voltages		
	a) One minute power frequency dry & wet (rms)	kV	
	b) 1.2 / 50 micro second Impulse withstand voltage(Peak)	kV (Peak)	
iii)	Minimum total creepage distance of whole insulator– mm	mm	
iv)	Suitable for live washing	Yes/ No	
v)	Level of pollution		
3.16	Additional requirements		
i)	Minimum cantilever strength of arrestor assembly	kgs	
ii)	Maximum radio interference voltage	μV	
iii)	Type of mounting		
iv)	Whether insulating base required		
v)	Accessories required		
	a) Discharge counter		
	b) Grading ring		
	c) Clamps and connectors		
	d) Leakage current meter		
	e) Earth lead disconnector		
vi)	Purchaser conductor size		
	a) Line side		
	b) Earth side		
vii)	Visual discharge voltage		
viii)	Pressure relief valve	Yes / No	

Sl. No.	Description	Units	To Be Filled By Bidder
4	**Insulator**		
4.1	Bus post insulator		
i)	Type		
ii)	Cantilever strength	kgs	
iii)	Power frequency Puncture voltage		
4.2	Disc insulator		
i)	Voltage class		
ii)	Type / No		
iii)	Creepage distance	mm	
iv)	Minimum protected creepage distance	mm	
v)	Electromechanical strength		
vi)	Power frequency Puncture voltage		

2.31.2 Recommended Additional Spare Parts

List hereunder the spare parts which are recommended by the Contractor for purchase in addition to the mandatory spare parts as per Chapter-33 of Volume IV, Section 7. The purchase of any or all of the recommended spare parts will be at the option of KHPL. The prices for recommended additional spare parts for five (5) years shall be quoted separately in the format provided in the Price Schedule (Section F).

Item	Description	Make/Type	Quantity
1			

* Use additional sheets if required

2.31.3 Information to be supplied together with the Bid

At least the information listed hereunder shall be given by the Bidder. The Bidder may submit additional documents /descriptions to describe special technical features of offered equipment / system:

i) Technical offer
ii) Dully filled Datasheet B
iii) Type test certificate.
iv) General Arrangement drawing
v) Catalogues
vi) Vendor list
vii) Transportation details

2.31.4 Lists of Tools & Instruments

List of tools and instruments shall be listed below in additional to the list provided by the employer.

Sl. No	Item/Description	Quantity offered
1	Assembly & erection tools	
2	Testing & Commissioning tools	
3	Testing and Commissioning instruments & devices	
4	Special tools & devices needed for routine maintenance purposes	

2.31.5 Similar Installations (in last 20 years) by the Contactor

Sl. No	Description	Name of owner/utility	Quantity supplied	Year of supply/ commissioning

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Data Sheet-2:

Schedule of Deviations from Specification

Name of Bidder:

All technical exception and deviations to the tender specifications shall be clearly set out by the bidder in the format given hereunder.

Sl. No.	Chapter, Clause & Page Number of specification	Exception & deviations from the tender specification proposed by the bidder	Justification for deviation

Certified that the above listed deviations and exceptions are exhaustive and the contract shall be executed as per the tender specification, excepting for the above deviations and exceptions in the event of placing an order on us.

Date: **Signature & Seal of Bidder:**

Place: **Name:**

Designation:

3 DATA SHEET-3: PROPOSED SITE ORGANIZATION

Name of Bidder:

1 **Preliminary Site Organization Chart ***

2 **Narrative Description of Site Organization Chart**

3 **Description of Quality Assurance at Site/Factory**

4 **Description of Relationship between Head Office and Site Management**

*** Note:** The details of foreign nationals (number and designation) to be deployed at site should also be

Date: **Signature & Seal of Bidder:**

Place: **Name:**

Designation:



4 DATA SHEET-4: PROPOSED WORK METHODOLOGY

Name of Bidder:

Method Statement

i) Method statement for basic engineering of the plant including preparation of design manuals.

ii) Method statement for detailed design of all Plant and Machinery and system(s).

iii) Method statement for manufacturing Plant and Machinery, shop assembly including shop testing.

iv) Method statement commensurate with equipment planning, project personnel, detail construction programme and milestones.

v) Method statement for packing and transportation of all Plant and Machinery manufactured in India/ abroad from manufacturer's works to Project Site.

vi) Method statement for site installation, land acquisition, storage areas, camps etc.

vii) Method statement for detailed planning, scheduling and Procedure for coordination with other contractors and suppliers, as well as with the Employer in such a way to avoid delays or other difficulties during the erection and testing of Plant and equipment.

The information submitted should be such as to allow an assessment of the general adequacy of the Bidder's proposal. Required number and classification of manpower, equipment and materials to be used for each particular activity should be described.

Date: **Signature & Seal of Bidder:**

Place: **Name:**

Designation:



5 DATA SHEET-5: DETAILS OF THE TECHNICAL & MANAGERIAL PERSONNEL AVAILABLE WITH THE FIRM RESPONSIBLE FOR DESIGN, MANUFACTURER, INSTALLATION, TESTING, COMMISSIONING AND TRAINING

Name of Bidder:

*For specific positions essential to contract implementation, Bidders should provide the names of at least two candidates proposed to meet the specified requirements. The data on their experience should be supplied in separate sheets using **Data Sheet 5A** for each candidate.*

1.	**Title of position**	
	Name of prime candidate	
	Name of alternate candidate	
2.	**Title of position**	
	Name of prime candidate	
	Name of alternate candidate	
3.	**Title of position**	
	Name of prime candidate	
	Name of alternate candidate	
Remark: *The Categories of Personnel includes Design, Production, Quality Assurance, Site Supervisory, Testing and Commissioning, Training, Managerial and Servicing etc.*		

Note:

1. Names proposed above will be posted against the work. Any change in name at later stage will require the approval of the Employer.
2. Project Manager designated for the Work shall have a minimum of twenty (20) years of total work experience and a minimum of fifteen (15) years in similar work.
3. Managers/Engineers designated for design, fabrication, testing/erection/commissioning and Quality Assurance & Control shall have a minimum of fifteen (15) years of total work experience and a minimum of ten (10) years in similar work.

Date: **Signature & Seal of Bidder:**

Place:

Name:

Designation:

6 DATA SHEET-5A: PERSONNEL CANDIDATE DATA

Name of Bidder:

Position		**Candidate** **( ) Prime ( ) Alternative**
Candidate information	**Name of candidate**	**Year of birth**
	Professional qualifications	
Present employment	**Name of employer**	
	Address of employer	
	Telephone	**Contact (manager/personnel officer)**
	Fax	**E-mail**
	Present job title of candidate	**Years with present employer**

Summarize professional experience to meet the specified requirements, in reverse chronological order. Indicate particular technical and managerial experience relevant to the Project.

From: month/yr.	**To: month/yr.**	**Company**	**Project (country)/Position/Relevant technical and management experience**

Date: **Signature & Seal of Bidder:**

Place: **Name:**

Designation:

7 DATA SHEET-6: SCHEDULE OF DESIGN, MANUFACTURING, SUPPLY, ERECTION, TESTING & COMMISSIONING WORK PROGRAM

Name of Bidder:

Submit a construction program for Design, Manufacturing, Supply, Erection, Testing & Commissioning of various equipment & systems related to KEM-1 works in bar chart form by using a latest project management software Primavera indicating activities starting with date of issuance of Letter of Acceptance and completing within scheduled time as specified in Appendix to Tender.

The Construction Program shall show various activities and their period including interdependent milestones specified in Appendix to Tender. This program should be based on the civil activities as per attached Construction Schedules of Civil contract.

Date: **Signature & Seal of Bidder:**

Place: **Name:**

Designation:



8 DATA SHEET-7: MOBILIZATION SCHEDULE/CONTRACTOR'S CONCEPT DESIGN

Name of Bidder:

The Bidder shall demonstrate when he proposes to mobilize plant equipment, materials, labour and other resources to deliver the Works in accordance with the requirements of the Specification. The schedule shall be logically linked to the Method statement and the Construction Schedule/ Program and to the Technical Proposals for Personnel and Equipment**.**

Date: **Signature & Seal of Bidder:**

Place: **Name:**

Designation:

9 DATA SHEET-8: QUALITY ASSURANCE PLAN AND PROCEDURES

Name of Bidder:

Bidders should provide the necessary information on Quality Assurance Plan containing the overall Quality Management System and Procedures to be followed during various phases of execution of the Contract.

Date: **Signature & Seal of Bidder:**

Place: **Name:**

Designation:



10 DATA SHEET-9: DETAILS OF THE MANUFACTURING CAPACITY OF THE FIRM (FOR TURBINE, GENERATOR & OTHER EQUIPMENT'S)

Name of Bidder:

SL. No	Manufacruring Facilities/Machinieries	Capacity/Location

Date:

Place:

Signature & Seal of Bidder:

Name:

Designation:

11 DATA SHEET-10: SCHEDULE OF TRANSPORTATION WEIGHTS & DIMENSIONS

Name of Bidder:

SL. No	Item/ Description	Qty	Dimensions (LxBxH) in mm	Weight (Tonnes)(Kg)

Date: **Signature & Seal of Bidder:**

Place: **Name:**

Designation:

12 DATA SHEET-11: INFORMATION REGARDING THE ITEMS TO BE MANUFACTURED/SUPPLIED BY SUB-SUPPLIER AND LIST OF SUCH SUB-SUPPLIER

The bidder shall indicate here the name of manufacturer/supplier from whom he proposes to purchase the standard items for accomplishment of works

Name of Bidder:

SL. No	Items	Name of manufacturer/Supplier	Place of Manifacturer/Supply

Date:

Place:

Signature & Seal of Bidder:

Name:

Designation:

13 DATA SHEET-12: LIST OF CONTRACTS IN HAND AND BIDS SUBMITTED FOR TURBINE, GENERATOR, MIV, ETC.

Name of Bidder:

SL No	Project Name	Name of Client, full address & Country	Nature of equipment installation	Detail of equipment and Quantity	Date of Award	Present Status	Expected Completion date	Value of the Contract
1	2	3	4(a)	4(b)	5	6	7	8
A	List of completed Contracts							
i.								
ii.								
B	List of ongoing contracts							
i.								
ii.								
C	List of bids submitted							
i.								
ii.								

Date: **Signature & Seal of Bidder:**

Place: **Name:**

Designation:



14 DATA SHEET-13: SPACE REQUIREMENT FOR STORAGE, COLONIES, OFFICES AND JOB FACILITIES

Name of Bidder:

SL. No.	**Description**	**Space Requirement (Square feet)**	**Expected Time Schedule**	**Remark, if any**
1.	Space for storage for equipment a) Outdoor b) Indoor			
2.	Space for Colonies, Offices			
	Total requirement of space			

Date: **Signature & Seal of Bidder:**

Place: **Name:**

Designation:

15 DATA SHEET-14: CONSTRUCTION POWER LOAD REQUIREMENT

Name of Bidder:

The construction power for the projects at various work fronts like Dam site, ADIT portal, Surge Shaft and Powerhouse etc. shall be arranged and provided by the Employer at 33 kV bus. The Contractor shall make arrangements beyond the facilities provided by the Employer as above for drawing construction power to their various sites, colonies, offices and associated areas of the Contractor within areas of Khorlochhu Hydro Power Project sites.

The bidder shall submit the construction power requirements in kW at each sites in the format given below:

PROFORMA FOR POWER LOAD REQUIREMENT

Sl. No.	Location/Purpose	Load requirement (KW)	Expected Time Schedule	Remark
	Total			

The electrical energy consumed by the Contractor shall be measured by a suitable meter installed at the point of supply, which shall be sealed in the presence of the Contractor or his authorized representative and read every month for determining the consumption of electricity. Each supply point shall be treated as separate connection.

Arrangements further distribution of power to the Contractor's sites, plant, equipment and machinery, workshop, colonies and offices from the point of supply shall be made by the Contractor at his own cost. The electrical installation plan shall be submitted for approval of the Employer.

Date: **Signature & Seal of Bidder:**

Place: **Name:**

Designation:



16 DATA SHEET-15: CONFIRMATION OF THE SITE VISIT BY THE BIDDER

Name of Bidder:

We……

……(Name of Bidder) whose registered office is at……
…… declare herewith that our representatives have visited the site of the works on……day of ……20…. ……., and that we have fully informed ourselves of all conditions, local and otherwise, which may affect the preparation of this bid and the performance of works.

Give names and positions of the representative(s) who took part in the site visit(s):

Name:…….. Signature:……..

Position:…….. Date:……..

Representative of…….

……

Name:…….. Signature:……..

Position:…….. Date:……..

Representative of…….

……

Name:…….. Signature:……..

Position:…….. Date:……..

Representative of…….

……

Date: **Signature & Seal of Bidder:**

Place: **Name:**

Designation:

17 DATA SHEET-16: BREAK DOWN OF PRICES

(To be submitted later, if required by the Employer)

Name of Bidder:

Note: *Bidders are not required to complete this Data Sheet at the time of preparation of Bids. Only the Bidders, who are requested by the Employer will submit the analysis of unit rates as per the format below in accordance with the Instructions to Bidders. (Clause 27.1).*

Bidder shall provide the breakdown of such Unit Prices as the Employer may determine, in accordance with the form shown hereunder. This cost breakdown shall include the breakdown of cost, overhead and profit. This form shall become part of the Contract and no claims may be made against the Employer for excess or deficiency therein whether actual or relative to other items.

Item No._____ (in the Schedule)

Work:_____

Unit Price:

Local component : _____

			Foreign Currency		Local Currency	
Particular Description (by item):	Unit	Quantity	Rate	Amount	Rate	Amount
1. Material costs						

Sub-total 1			----------		----------	
2. Manpower costs (by grade, except supervisory and managerial staff)						

Sub-total 2			----------		----------	
3. Plant and equipment costs (by type)						

Sub-total 3			----------		----------	
4. Costs of supervisory and managerial staff						

	Sub-total 4	----------	----------
5.	Other direct		

	Sub-total 5	----------	----------
6.	Indirect costs, if any		

	Sub-total 6	----------	----------
7.	Overhead and profit		

	Sub-total 7	----------	----------
	Total 1+2+3+4+5+6+7	==========	==========

Signature: _____

Title and position: _____

18 DATA SHEET-17: ADDITIONAL/SUPPLEMENTAL INFORMATION

Name of Bidder:

Add any further information that the Bidder considers to be relevant to the evaluation. If the Bidder wishes to attach other documents, list them below.

Bidders should not enclose testimonials, certificates, and publicity material with their applications; they will not be taken into account in the evaluation of qualifications and will be discarded.

SL. No.	Description of work	Stipulation in Specification (Clause/Section no. need to be mentioned)	Additional Information

Date: **Signature & Seal of Bidder:**

Place: **Name:**

Designation: