BHARAT HEAVY ELECTRICALS LIMITED
TRANSMISSION BUSINESS ENGINEERING MANAGEMENT
NOIDA

DOCUMENT NO.	Doc No. TB-GIS-KHORLOCHHU-BHUTAN2	Rev 02	Prepared	Checked	Approved
TYPE OF DOC.	TECHNICAL SPECIFICATION	NAME	JK	VK	VK
TITLE		SIGN			
		DATE	02/12/2025	02/12/2025	02/12/2025
		GROUP	TBEM		
400 kV Gas Insulated Switchgear with its accessories		WO No.			

CUSTOMER	KHORLOCHHU HYDRO POWER PROJECT (KHPL)
CONSULTANT	--
PROJECT	Pre-Bid Tie up for 400kV GIS Substation Package for 4x150 MW KHORLOCHHU HYDROPOWER PROJECT TRASHIYANGTSE; BHUTAN

Contents

Remarks: Bidder to note that data and details of Guaranteed Technical Particulars shall not be reviewed during Technical Evaluation/ Review, hence compliance of Guaranteed Technical Particulars in line with Technical Specification has to be ensured by the bidder.

Rev. No.	Date	Altered	Checked	Approved	
Distribution				To	
				Copies	

ANNEXURE - A
SCHEDULE OF TECHNICAL DEVIATIONS

Bidder shall list out all technical potential deviation/ change request (s) along with clause with respect to technical specifications.

Sl. No.	Page No.	Clause No.	Deviation	Reason / Justification

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Any deviation not specifically brought out in this section shall not be admissible for any commercial implication at later stage. Except to the technical deviations listed in this schedule, bidder's offer shall be considered in full compliance to the tender specifications irrespective of any such deviation indicated / taken elsewhere in the submitted offer.

NIT Reference No.:

Name of Bidder:

Name of Project:

Date: Bidder's Stamp & Signature

Annexure B- CHECKLIST FOR TECHNICAL BID

Along with the technical offer/ bids, the bidder should submit this documents confirming the inclusion of the enclosures as listed below,

Sl. No.	Documents to be enclosed	Bidder to confirm submission with technical bid (Please tick "Confirmed")
1.	Technical offer.	Confirmed
2.	Preliminary Gas SLD	Confirmed
3.	Preliminary GAS layout.	Confirmed
4	Technical Data sheet of all major items.	Confirmed
5	Type test certificates valid for years (as per TS) for all equipment/ plants/ accessories being supplied under this CONTRACT.	Confirmed
6.	Supporting documents for compliance of Technical Qualifying Requirement.	Confirmed
7.	Unpriced BOQ duly mentioning "Quoted" for all the items, signed and sealed.	Confirmed
8	Schedule of Technical Deviation	Confirmed

The above checklist is reviewed and verified for,

NIT Reference No.:

Name of Bidder:

Name of Project:

Date: Bidder's Stamp & Signature

Name of Bidder
Email ID
Contact Details

	Annexure – Amendments to Technical Specification				**Dated: 02-12-2025**
Project: 4x150 MW KHORLOCHHU HYDROPOWER PROJECT, TRASHIYANGTSE, BHUTAN (Contract Package: KEM-I) **Client: KHORLOCHHU HYDRO POWER LIMITED**					
Sr No	Document	Clause No & Page No.	Topic	Description of customer requirement	Amendmened as follows
1	Volume 4: GTS, PTS, QAP Section – 7: Particular Technical Specification	9.32 - 3.6	Employer's speci	Material For Bus-Bar Electrolytic COPPER (The PTS specifies bus bar material as Aluminium Alloy, however the Data Sheet A1 (3.6) ask for Electrolytic copper. Bidder would like to inform that as per OEM Standard proven design, practice and type tested Al alloy busbar will be provided. Kindly accept.)	As per Bidding Document or OEM's Standard Design
2	Chapter 9, Cl. No. 9.19.1 Circuit breaker (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.	As per Bidding Document or OEM's Standard Design
3	9.3 Components of GIS Assembly			vii) Partial Discharge Monitoring devices (where applicable)	PORTABLE PARTIAL DISCHARGE MEASUREMENT TEST KIT IS TO BE CONSIDERED AS PER bps
4	Volume 4: GTS, PTS, QAP Section – 7: Particular Technical Specification	9.19.2 / 230	Circuit Breaker	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.	As per Bidding Document or OEM's Standard Design

	Annexure – Amendments to Technical Specification				Dated: 02-12-2025
Project: 4x150 MW KHORLOCHHU HYDROPOWER PROJECT, TRASHIYANGTSE, BHUTAN (Contract Package: KEM-I) Client: KHORLOCHHU HYDRO POWER LIMITED					
5	Volume 4: GTS, PTS, QAP Section – 7: Particular Technical Specification: Clause 9.25.4 Relays			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	Not considered for GIS
6	General			GIS Floor - Expansion Joint	Bidder to consider Two positions for building expansion joints in the offer. The cost of the same shall be deemed inclusive. Addition / deletion shall be operated as per BPS
7	Pg 38 of 257 of TS			HOOK Height	Maximum Hook height of 8.6 meter shall be made available.
8	Volume 4: GTS, PTS, QAP Section – 7: Particular Technical Specification Clause 9.19.1			xiv) Breaker disposition must be horizontal to provide higher mechanical stability and ease in maintenance.	Bidder may propose a horizontal / vertical design, subject to the feasibility of their GIS. Supporting documents demonstrating suitability for operation, maintenance, and repair at the specified position and hook height shall be provided during detailed engineering stage.
9				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.	Bidder to comply IEC standrads for BIL level.
10	Volume 4: GTS, PTS, QAP Section – 7: Particular Technical Specification Clause 9.8			iii) Double “O” ring design be adopted to ensure Gas tightness. The material and method of sealing used shall be stated in the tender.	As per Bidder's Type Tested Design sigle seal may be accepted.
11	General			zone trip logic	The zone trip logic shall be developed in the LCC by the GIS manufacturer. Any contact multipliers and/or additional contacts required in the density monitors shall be provided by the GIS manufacturer.

Contents

This document covers broader guideline for bidder's scope of supply & services. The same shall be prevailing on all other section of technical specification.

1. SCOPE

This technical specification covers the requirements of (1.) design, type testing, engineering, fabrication, manufacturing, shop assembly, inspection and testing at manufacturer's works, proper packing, supply and delivery to project site, (2.) supervision of material reconciliation, installation / erection, (3.) execution of site testing & commissioning along with necessary kits, tools & equipment , putting GIS with LCC & its Accessories into successful operation complete with all materials, support structures, anchoring bolts, chemical anchor, accessories, commissioning spares & maintenance spares, special spanners, special tools & tackles, any specific required ancillary services, SF6 gas for first filling & spare etc. including design studies, training of BHEL / Customer personnel for offered GIS & its Accessories complete in all respects for efficient & trouble-free operation mentioned under this specification.

The complete technical specification comprises of following sections:

Section-1	:	Scope, Project Specific Technical Specification & Bill of Quantities
Section-2	:	Equipment Specification under scope of Supplies
Section-3	:	Project Details & General Technical Requirements (For All Equipment under the Project)
Section-4	:	Annexures Annexure A- Compliance Certificate Annexure B- Schedule of Technical Deviations

The following order of priority shall be followed. In case of conflict between requirements specified in various documents, the more stringent one shall be followed. BHEL/Customer concurrence shall, however, be obtained before taking a final decision in such matters.

1. Statutory Regulations
2. Section-1(PART-A) Standard Scope Matrix
3. Section-1(PART-B)
4. Section-2
5. Section-3

Bidder shall furnish list of conflicts/ ambiguities/ deviations, if any, along with their technical offer and also furnish the basis that is considered for submitting technical offer. BHEL will address the bidder's listed conflicts prior to award. In case of ambiguity, bidder shall inform BHEL of their interpretation. In case bidder fails to convey the same prior to award, BHEL decision on interpretation shall be considered final if need arises during the execution. No additional cost or extra time on account of conflicts/ ambiguities/ deviations shall be admissible.

In general, no deviation from the requirements specified in various clauses of this specification shall be allowed and hence, a certificate to this effect shall have to be furnished along with the offer (Annexure-A), however bidder shall furnish list of conflicts/ ambiguities/ deviations (Annexure-B), if any.

Please note, any deviation not specifically brought out in Annexure-B (Schedule of Technical Deviations) shall not be admissible for any time and commercial implication at later stage. Except to the technical deviations listed in this schedule, bidder's offer shall be considered in full compliance to the tender specifications irrespective of any such deviation indicated / taken elsewhere in the submitted offer. Any conflicts/ ambiguities/ deviations mentioned elsewhere in technical offer shall not be reviewed.

The scope of supplies shall be as per commercial terms and conditions enclosed separately with the notice inviting tender/ enquiry.

2. SPECIFIC TECHNICAL REQUIREMENTS

Project specific technical requirements shall be as per Section-1 (Part-B) of technical specification.

3. GENERAL TECHNICAL REQUIREMENTS (Part-1 of 2)

1. SF6 gas for initial installation of complete GIS System, including wastage during installation, testing and successful commissioning shall be deemed included in the bidder's scope. Manufacturer to supply additional qty so as to cater the losses during installation, testing & commissioning.
2. The offered GIS with LCC & its Accessories shall be complete in all respect in compliance to technical specification and relevant IS / IEC / IEEE standards as applicable. Any other equipment/material required to complete the specified GIS scope of work are inclusive of bidder's scope of supply & services.
3. All essential and desirable accessories are deemed inclusive of offer i.e. and not limited to Gas Monitoring Devices, Pressure Switches, PD sensors, Pressure relief device, insulator, expansion joint/ flexible, bellows/ compensators like lateral mounting units, Axial compensators, Parallel compensators, tolerance compensators and vibration compensators etc. complete in all respect.
4. Total contract value may vary up to ±20% at contract stage.
5. Any Item not quoted mentioned "**Not Applicable**" in bid price schedule and found applicable as per technical specification and system requirement shall be supplied free of cost by bidder without any time / cost implication to BHEL / Customer.
6. Length & route of GIB is purely indicative and same shall be finalized during detailed engineering stage.
7. BHEL reserve rights to amend Bay sequence during contract stage, no separate claim shall be admissible in this regard.
8. Supply scope of Testing & Maintenance Equipment – Scope of supply of following Equipments shall be applicable exclusively if covered in BOQ / BPS. However same shall not be used for erection/ installation, testing and commissioning of GIS, hence bidder to bring Special Tools &, tackles, Testing & Maintenance Equipment/ Instruments at site for during erection/ installation, testing & commissioning on returnable basis.
    a. SF6 Gas leakage detector
    b. Gas filling and evacuating plant: (Gas Processing unit)
    c. SF6 gas analyser
    d. Portable Partial Discharge(PD) monitoring system
    e. Online Partial Discharge Monitoring System
9. Main Bus 1 / 2 / Transfer Bus etc. Gas Insulated Bus Bars running across the length of the switchgear to interconnect each of the bay modules (as per layout) and necessary interfaces (as applicable under the technical requirement) is

deemed inclusive in the scope. The same may or may not be indicated with break-up in BOQ / BPS.

4. GENERAL TECHNICAL REQUIREMENTS (Part-2 of 2)

Other general requirements GIS with LCC & its Accessories shall be as follows,

1. Guaranteed Technical Particulars: Bidder to submit detailed GTP in line with technical specification during contract stage for review and approval. GTP & drawings submitted with technical bid shall only be reviewed during contract stage only. Bidder to please note, deviations / conflict if any please be mentioned in schedule of technical deviations only.
2. The positioning of the circuit breaker in the GIS shall be such that it shall be possible to access the circuit breaker of any feeder from the front side for routine inspection, maintenance and repair without interfering with the operation of the adjacent feeders.
3. The physical layout shall ensure free movement of the SF6 Gas Cart and easy access to all components of the GIS for operation and maintenance purposes.
4. Bidder shall submit list of consumables with shelf life of less than six months and same shall be dispatched before commencement of erection or after clearance from BHEL/Customer whichever is earlier. No separate dispatch clearance shall be required for consumables. The service activities shall include consumables/ commissioning spares required during commencement of GIS installation, testing and commissioning in all respect. Cost of the same deemed inclusive.
5. Bidder shall offer their latest type tested model to accommodate the specified & allocated space as per attached layout drawing of GIS.
6. Bidder shall conduct insulation co-ordination studies in line with IEC for establishing surge arrester rating, quantity and any other requirement for successful operation of GIS. however, additional supply of surge arrester in line with above required shall be paid as per Bill of Quantity, as applicable.
7. Bidder to submit Study report of VFTO generated for 400kV GIS installation.
8. Bidder shall check and ensure adequacy of system protection for successful operation of GIS. After checking of system by bidder, GIS shall be installed and if any failure, malfunction of any part occurs after/ during commissioning, same shall be replaced immediately without any extra cost.
9. Final documentation shall be submitted in hard copy (Four prints) and soft (Three

CDs/DVDs)

10. In the case if CSD is specifically called in BPS / BOQ / Section-1(PART-B) of technical specifications, the same should have display facility at the front for the display of settings and measured values. In case where CSD does not have complete display facility for settings and measured values, bidder to supply one number laptop PC with pre-installed, licensed software for each site. Special cable required for integration is deemed inclusive in bidder's scope.
11. Bidder to submit all supporting documents in English. If document submitted by bidder is other than English language, self-attested English translated document should also be submitted.

5. MODE OF MEASUREMENT FOR GIB DUCT

1. The price of Bus-duct inside the GIS hall (up to **outer** wall face of GIS Hall) shall be integral part of the respective bay module and it will not be paid separately. However, the payment of bus-duct for outside the GIS hall along with support structure shall be paid as per running meters in line with provision of Technical Specification & Bid Price schedule.
2. In the case of outdoor type GIS, Gas Insulated Bus Duct (GIB) length of bus duct outside the GIS BAY MODULE shall be considered for mode of measurement from the end of Bay equipment (VT, LA etc.) to end equipment (SF6 to air bushing / SF6 to oil bushing/ Cable connection module etc.).
3. Any change in bay pitch (distance between bays): In a case where shifting of GIS bays shall be called by BHEL (during contract stage) due to layout requirement / cost optimization / revision / change in civil architectural requirement or due to expansion joint requirement in the GIS building, Bidder to incorporate the same with full compliance of technical requirement. Payment equivalent of BPS / BOQ item under head "Gas Insulated Bus Duct" shall be operated for additional length of Main Bus, subject to such shifting is not attributed to bidder.

6. STRUCTURE & HARDWARE (INCLUDING STRUCTURE STEEL)

Structural Steel, Support Structure, Walkway, Inserts & Hardware (required for installation & operation of complete GIS system with LCC & its Accessories etc.) are deemed inclusive of bidder's scope of supply. The same may or may not be indicated

with break-up in BOQ / BPS.

All steel structure members shall be hot-dip galvanized after fabrication (excluding floor embedded items for which standard practice is to be followed). All field assembly joints shall be bolted. Field welding shall generally not be acceptable. Noncorrosive metal or plated steel shall be used for bolts and nuts throughout the work.

The minimum weight of the zinc coating shall be 610 gm/sq.m and minimum average thickness of coating shall be 86 microns for all items having thickness 6mm and above and 900 gm/sq.m for coastal area (if defined in Section-1B / Section-2 of technical specification) For items lower than 6mm thickness requirement of coating thickness shall be as per relevant ASTM. For surface which shall be embedded in concrete, the zinc coating shall be 610 gm/sq.m minimum and **900 gm/sq.m for coastal area** (if defined in Section-1B / Section-2 of technical specification).

1. Lattice / Pipe structure Materials for support of GIS, Bus Ducts, SF6 to oil bushing/ SF6 to cable connection and SF6 to air bushing/ connection including Anchor Fastener Bolts, Foundation Bolts, Base Plate / Channel / Metallic / Structural Member for seating of GIS system, all floor and wall Embedded Items, wall crossing arrangements, Rails and/ or other items structural items as required. Manufacturer shall provide suitable foundation channels and anchor bolts to support the switchgear assemblies. All mounting bolts, Anchor Fasteners, foundation bolts, nuts and washers, equipment fixing hardware shall be provided to fasten the switchgear base frames to the foundation channels as applicable
2. Chemical / Mechanical Anchors Bolts are to be provided by bidder for GIS, GIB & SAB.
3. 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.
4. Structural steel for complete GIS system with LCC & its Accessories is deemed inclusive in bidder's scope of supply.

7. EARTHING MATERIALS OF GIS

1. Earthing material of GIS are deemed inclusive of bidder's scope of supply. The same may or may not be indicated with break-up in BOQ / BPS.
2. Bidder to submit detailed calculations and layout drawings for earthing system during detailed engineering stage based on technical specification, bidder's design philosophy, IS/IEC/IEEE requirement as applicable. Bidder to provide the bill of quantity of entire GIS system with LCC & its Accessories
3. Supply of 40 mm MS ROD, 75X12 mm GI Flat, 50X06 mm GI Flat is not in bidder's scope of supply.

4. **COPPER GROUNDING MESH FOR GIS**: Bidder to consider scope of Copper Flat & hardware supply as follows

A. If Requirement is called in Technical Specification	
a. Bidder's Scope of Supply	If covered in BOQ / BPS.
b. Not in Bidder's Scope of Supply	If not covered in BOQ / BPS.
c. In case COPPER GROUNDING MESH concluded as Not in Bidder's Scope of Supply (i.e. BHEL scope of supply) : Copper Riser Connection for GIS equipment Shall be brought approximately **200** mm above the FINISHED FLOOR LEVEL shall be supplied by BHEL. Onward earthing connections for GIS equipment shall be in the scope of the bidder.	

B. If Requirement is not exclusively called in Technical Specification but required as per manufacturer's design	
a. Bidder's Scope of Supply	Required, even if a separate BOQ / BPS item is not indicated.

1. **All** other materials, including onward risers, earthing materials, hardware (nuts, bolts, washers, lugs, etc.) required as per the earthing design, shall be included in the GIS Manufacturer's scope of supply. However, the installation/erection of earthing will be carried out by the BHEL team under the supervision of the bidder/manufacturer, in accordance with the manufacturer's design.
2. Installation/ erection/ laying of earthing system for GIS shall be done by BHEL/ its contractor, however, supervision shall be provided by bidder as per approved design philosophy.
3. Special requirement for earthing (as mentioned in Section-2) shall be duly taken

care while designing the earthing system for GIS and its associated system.

Remark:- BPS: Bid Price Schedule & BOQ: Bill of Quantity with TS

8. INTERNAL CABLES

1. Power, control & instrumentation cables for **Cabling** (1.) within GIS, (2.) GIS to LCC, (3.) LCC to LCC (excluding incoming power cable) shall be deemed inclusive in bidder's scope of supply. The same may or may not be indicated with break-up in BOQ / BPS.
2. Scope includes for completeness for GIS system with LCC & its Accessories
3. Cabling between LCC to LCC shall be applicable if required in bidder's design philosophy.
4. Cables required for bidder supplied GIS sub-system i.e. condition monitoring system (Gas monitoring system, PD monitoring system etc) are to be supplied by bidder as complete system.
5. Necessary Cable Lug, Glands & shroud etc. required for installation of bidder's supplied cable are deemed inclusive in bidder's scope.
6. Bidder to provide detailed "Bill of Quantity" during detailed engineering stage. Cabling & termination schedule for the same shall be provided by successful bidder along with AS BUILT drawing during contract stage.
7. Power Cable TB's (for both AC & DC incoming feeder cables) shall be suitable for termination of requisite cable.

9. DRAWINGS / DOCUMENTS FOR MANUFACTURING CLEARANCE

The drawings/ documents, as follows shall be used for providing technical clearance for manufacturing of GIS and furthermore, it shall be used for delay analysis, if any, from bidder. The first drawing submission will be counted from the date of submitting reasonably correct drawings.

Sl. No.	Overall Drawings approval required in Cat I /Cat II
LOT-1	
1	GIS- Gas Schematics with Single Line Diagram (Including CT VT

	Parameters)
2	GIS- Guaranteed Technical Particulars (Including all GIS equipment)
3	GIS- Layout Plan & Section
4	GIS- Interfacing Drawings for Cable Connection Module / SF6 to Air Bushing / SF6 to Oil Module (as applicable under scope) with Guaranteed Technical Particulars
5	GIS- Type Test Reports (Including all GIS equipment)
6	GIS- Quality Assurance Plan & Inspection Test Schedule
LOT-2	
7	GIS- Secondary Engineering Base Design & Control Schematics for GIS and Local Control Cabinet
8	GIS- Maintenance Equipment Catalogue with Guaranteed Technical Particulars, test reports
9	GIS- Civil Design Specification with Foundation Loading Diagram (Including interfacing details)
10	GIS – Support Structure, Platform, Wall & Floor Inserts & Hardware drawing & BOM
11	GIS- Earthing Layout with Design
12	GIS- Quantification for main Items, Spares, Consumables
13	Design Calculations (Having interface on GIS Manufacturing)
OTHER	
14	GIS- 3D OGA Drawing (3D-Model with complete editable data base) compatible with Autocad & Primtech for complete GIS & its accessories.
15	Manuals on unloading, safe storage, transportation, installation, testing, commissioning, routine check, preventive maintenance

10. TYPE TEST

Please refer Section-1(PART-B) and Section-2 of technical specification for the details of type test requirement. All equipment being supplied shall conform to type tests as per technical specification and shall be subject to routine & acceptance tests in accordance with requirements stipulated under respective sections of technical specification.

11. QUALITY PLAN

Bidder to follow valid customer approved (1.) Manufacturing Quality Pan, (2.) factory acceptance test (FAT) procedure & (3.) Site acceptance test (SAT) procedures, as per Customer procedure. In case the bidder doesn't have Customer approved Quality Plan, it will be the bidder's responsibility to get its Quality Plan approved from the ultimate Customer within 30 days from the date of issue of after award of LOI / PO whichever is earlier.

All materials shall be procured, manufactured, inspected and tested by vendor/ sub-vendor as per approved quality plan. The supplier shall perform all tests necessary to ensure that the material and workmanship conform to the relevant standards and comply with the requirements of the specification.

GIS and its associated materials shall be subject to inspection by BHEL/ Customer / authorized representative at bidder / manufacturing works. Hence, Bidder shall furnish all necessary information concerning the supply to BHEL. During fabrication, the equipment shall be subject to inspection by BHEL/ Customer or by an agency authorized by BHEL/ Customer to assess the progress of work as well as to ascertain that only quality raw material is used.

12. SITE SERVICES

Site service activities shall be carried out at in stages as per requirement or front availability at site, and hence multiple visits for completion of work are envisaged as per site requirements hence any claim in this regards shall not be admissible on account of multiple mobilization or idling during project execution stage.

12.1. SUPERVISION AT SITE

1. Supervision of complete installation / erection of GIS with LCC & its Accessories are in the scope of bidder.
2. Scope also includes verification of materials for proper storage with due

instructions/ training to site persons for long storage.

3. Standard storage instruction manual specifically specifying the item detailed with details of type of storage.
4. Supervision for reconciliation and spares / accessories and handing over to customer.
5. Final documentation including AS BUILT documents

12.2. TESTING & COMMISSIONING

1. The complete GIS System shall be subjected to the site tests as per technical specifications, IEC-62271-203. Bidder to submit site acceptance testing (SAT) procedures and get the same approved from BHEL / Customer before carrying out the site testing at site.
2. Carrying out successful HV/ Power Frequency Testing of GIS as per IEC shall be in scope of bidder, which includes HV test kit with operator, accessories & tools required for completion of HV testing. Bays may be commissioned separately.
3. BHEL shall provide extend support and assistance at site for smooth conduction of HV Testing including unloading, assembling of HV test kit, dismantling, packing & loading back for transportation.
4. Complete Field testing and commissioning of GIS system with LCC & its Accessories are under the scope of Bidder.
5. Bidder supplied special equipment, T&P if required OEM supervision, the same is to be arranged by bidder, cost of the same shall be deemed inclusive of respective item.
6. Bidder/ OEM shall coordinate with manufacturers of other equipment wherever required and shall freely and readily supply all technical information for this purpose as and when called for.
7. ETC work schedule for all the GIS may vary according to readiness of site. Respective dates for the commencement of erection, testing and commissioning activities of GIS shall be communicated to manufacturers from time to time as per the readiness of site.

13. TESTING KITS, TOOLS & TACKLES

1. All the Instruments/ Testing kits including HV Test Kit, SF6 Gas handling Equipments required for successful installation, testing, commissioning, maintenance of offered GIS are to be arranged by bidder on **returnable** basis. Cost of the same shall be deemed inclusive in the offer.
2. Special tools & tackles for installation, maintenance, testing & commissioning of GIS shall be in bidder's scope, it shall be brought at site on **returnable** basis only.
3. The general Tools and Tackles shall be provided by BHEL, list of the requirement i.e. general tools-tackle, spanners, gauges, slings and other lifting devices, crane, welding machines, drills, general instruments and appliances necessary for the installation of GIS is to be submit by bidder along the technical bid. In case bidder fails to convey the same along with technical bid, BHEL decision on interpretation of general tools tackle shall be considered final and any tools & tackles required shall be brought at site by bidder without any claim.
4. Bidder to furnish detailed BOQ for non-returnable special Tools and Tackles, if applicable along with unit prices to be handed over to ultimate customer. The prices for the same shall be considered during evaluation.

14. SPARES

1. Any equipment which is not supplied as main equipment or part of main equipment, mandatory spare for that is not applicable.
2. In case contractor offers circuit breaker, dis-connector, current transformer, SF6/Air Bushing etc. under main equipment of higher rating than equipment rating specified in the specifications, the mandatory spare of same higher rating offered by contractor identical to main equipment offered in the package shall be required to be supplied against spares without any cost implication.
3. The Mandatory Spares shall be included in the bid proposal by the bidder. The prices of these spares shall be given by the Bidder in the relevant schedule of Bid Price Schedule and shall be considered for evaluation of bid. It shall not be binding on the Employer to procure all of these mandatory spares.
4. The bidder is clarified that no mandatory spares shall generally be used during the commissioning of the equipment.
5. Start-up & Commissioning spares are included in bidder’s scope of supply and

shall be included in the base price. Adequate stock of start-up & commissioning spares shall be made 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 Purchaser can be carried out without any hindrance or delays. The unutilized Start-up & Commissioning spares brought for commissioning purpose by bidder shall be taken back by the bidder.

6. Wherever spares in BPS / BOQ/Technical Specification have been specified as "each type/each rating/each type & rating": If the offered spare/spares is sufficient to replace the respective main equipment of all types/ratings, then such offered spare/spares shall be acceptable. It implies that common spare/spare set fulfilling the spare requirement of all types/ratings shall also be acceptable, provided it is configurable at site itself without special assistance of OEM.
7. Mandatory Spares, wherever mentioned, are envisaged for the equipment/items being supplied under the main equipment heads under present scope meeting the requirements of Technical Specifications. The component/sub-component of an equipment/item specified in BPS / BOQ under Mandatory Spare, which is not applicable as per the offered design of respective main equipment, shall not be referred to.
8. Bidder to submit price break-up of spares during tender stage. It shall not be binding on the BHEL to procure all of these mandatory spares.
9. Bidder/ vendor shall ensure the availability of spare parts and maintenance support services for the offered equipment at least for 15 years from the date of supply. Bidder shall give a notice of at least one year to the Customer & BHEL (both) before phasing out the products/spares to enable the owner for placement of order for spares and services.

15. PACKING AND DISPATCH

1. The equipment shall be carefully packed for transport by sea, rail and road in such a manner that it is protected against the climatic conditions and for any damage during transportation, transit and storage. Packing of the equipment shall be suitable for long storage (minimum 1 year).
2. The GIS transport units shall be shipped in the largest factory assembled units within transport and loading limitations and considering handling facilities on site to reduce the erection and installation work on site to a minimum. Where possible all items of equipment or factory assembled units shall be boxed in substantial

crates or containers to facilitate handling in a safe and secure manner.

3. Each individual piece to be shipped, whether crate, container or large unit, shall be marked special notations such as 'Fragile', 'This side up', 'Centre of gravity', 'Weight', 'Owner's particulars', 'PO no.' etc., and other details as per purchase order & technical specification.
4. The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage in areas with heavy rains and high ambient temperature.
5. Special precautions shall be taken to protect any parts containing electrical insulation against the ingress of moisture. This applies particularly to the equipment of which each gas section shall be sealed and pressurized prior to shipping. Dry nitrogen/air or dry SF6 gas (in full compliance to technical requirement) shall be used and the pressure shall be such as to ensure that, allowing for reasonable leakage, it will always be greater than the atmospheric pressure for all variations in ambient temperature and the atmospheric pressure encountered during shipment to site and calculating the pressure to which the sections shall be filled to ensure positive pressure at all times during shipment.
6. All blanking plates, caps, seals, etc., necessary for sealing the gas sections during shipment to site shall be provided. Any seals, gaskets, `0' rings, etc. that will be used as part of the arrangement for sealing off gas sections for shipment of site, shall not be used in the final installation of the equipment at site. Vendor to provide quantity of components accordingly considering permanent installation and commissioning.

16. SPECIFIC- EXCLUSIONS (NOT IN BIDDER'S SCOPE)

The following items are specifically excluded from the bidder's scope of supply & services, irrespective of the same if covered under any section of technical specification other than Section-1 (PART-B). If specific requirement mentioned in the Section-1(PART-B) of technical specification shall overrule this specific exclusion.

1. Any scope of supply / services mentioned in Section-2 or Section-3 of technical specification but not having any relationship with GIS, LCC & its Accessories and not covered in Section-1(PART-B) or BPS / BOQ shall be deemed excluded from bidder's scope.

2. Installation / Erection of GIS with LCC & its Accessories except supervision work.
3. Cable laying & terminations, however supervision work & termination of special cables shall be in bidder's scope.
4. Open & Closed stores at site. (Bidder to provide space requirement in tech bid)
5. Local transportation/ conveyance for bidder's engineers shall be arranged by BHEL between local stay and site.
6. Office assistance shall be provided BHEL including sitting facility etc.
7. Receipt & unloading of material at site except supervision work
8. Terminal connector for SF6 to Air Bushing to conductor or any other interfacing equipment.
9. Watch & Ward of GIS material at BHEL Store
10. Civil Works i.e. GIS Hall, civil works requirement for GIS System. (Please refer clause "Structure-Steel" for bidder's scope of supply)
11. EOT crane, Air Conditioning & Ventilation System, Illumination System & Fire detection & alarm system, however complete input shall be provided for EOT and other system
12. Control Relay & Protection Panels, Numerical Relays, Bus Bar Protection Panel, SAS & ECS system, ACDB, DCDB, Battery & Charger
13. Earthing material i.e. 40 mm MS Rod, 50X6 GI Flat & 75X12 GI Flat for earthing
14. Outdoor AIS Equipments
15. Power & Control cable beyond LCC towards ACDB, DCDB, CRP, SAS etc
16. BHEL / Customer / BHEL appointed 3rd party inspector travel, lodging & boarding charges during testing / inspection.

Rev Number	Date	Initiated by	Reviewed by	Approved by	Updates
Rev.0	19 Feb 2022	JAIK	SKS	AG	
Rev.1	04 March 22	JAIK			Clause 4.1 revised Clause 3.9 added Clause 5 900 gm/sq.m for coastal area
Rev.2	09 March 22	JAIK			Clause 5 updated (yellow highlight)
Rev.3 & 4	22 March 24	JAIK / DKS			Clarification on Copper Grounding Mesh. Ref clause 2.10 & other clauses
Rev.5	07/10/2024	JAIK/DKS			

This technical specification is required for Pre-bid tie-up before participation in the following tender:

Name of the Customer	KHORLOCHHU HYDRO POWER PROJECT (KHPL)
Name of Main Contractor	Bharat Heavy Electricals Limited
Name of the Project/ Tender	Pre-Bid Tie up for 400kV GIS Substation Package for 4x150 MW KHORLOCHHU HYDROPOWER PROJECT TRASHIYANGTSE; BHUTAN
Location	TRASHIYANGTSE; **BHUTAN**

[1] SPECIFIC TECHNICAL PARAMETERS - Please refer SECTION-2

[2] BILL OF QUANTITIES: Please refer following

1. BOQ_400KVGIS_Khorlochhu

During tender stage No of bays of GIS may vary. No of bays of GIS shall be finalized after receipt of Notification of award (NOA) from CUSTOMER.
Overall contract value may vary +/- 20%.

[3] SPECIFIC TECHNICAL REQUIREMENTS

The scope of supply and services shall cover full compliance with the technical specifications, technical requirements, and all applicable standards to meet the project requirements stipulated in the following documents for successful commissioning.

1	**Key Single Line Diagram**	**KHPP-EL-PH-SLD-4006-AU-40001**
2	**Metering and Protection Single Line Diagram**	**KHPP-EL-PH-SLD-4006-AU-40002**

3	**Power House Cross Section**	**KHPP-ME-6017-GA-60001 (SHEET-1)**
4	**Transformer hall longitudinal section..**	**KHPP-ME-6017-GA-60001 (SHEET-4)**

1. Detailed technical requirement of GIS are as per **SECTION-2.**
2. **In case of discrepancies between data as required by Technical Specifications and those stated in the Technical Data Sheets, the Stringent Specifications take precedence.**
3. Any other items not specifically mentioned in the specification but which are required for erection, testing and commissioning and satisfactory operation of the substation are deemed to be included in the scope of the specification unless specifically excluded.
4. **End Piece (Interface) module** with Isolating test link for Future extension on one side of Auxiliary Bus bar module. The end piece module shall be designed in such a way so that future GIS module may be tested without extending voltage to existing bus by removing the test link.
5. Actions required in case of defects observed during warrantee period
    a. a) SF6 gas leakage: Repair/ replacement
    b. b) High Dew point of SF6 gas (> -36 deg C at atm press): Re-Processing of gas and replacement of Gas in case of no improvement
    c. Replaced/Repaired/Refurbished Equipment (or part of equipment) shall have 2 years warranty without prejudice to contractual warranty period.

[4] OTHER TECHNICAL REQUIREMENTS for GIS & OTHER ASSOCIATED EQUIPMENT:

1. **SF6 GAS** REQUIRED FOR PLACING GIS INTO SUCCESSFUL OPERATION - Complete in all respect in compliance to technical specification and requirements.
2. **STRUCTURE MATERIAL** INCLUDING ANCHOR / FOUNDATION BOLTS, EMBEDDED ITEMS, FLOOR / WALL OPENING, RAILS AND/ OR OTHER MATERIALS ETC - Complete in all respect for installation of complete GIS

system in compliance to technical specification and requirements. In the event of changes in present scope, payment shall be made on pro-rata basis of number of circuit breaker bays only.

3. 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.

4. **EARTHING MATERIAL –** Please review the "Reference Guidelines for GIS Grounding" in addition to Section-1 (Part-A) for a comprehensive requirement of the earthing material. Please note (1.) **40 mm MS ROD, (2.) 75X12 GI Flat & (3.) 50X6 Cu Flat for GIS Floor earthing & Riser up to max 200 mm above FFL are <u>NOT in Bidder's scope of supply</u>.**

[5] SPECIFIC TECHNICAL REQUIREMENTS FOR CSD

1. CSD shall be deployed for optimization of switching behavior of bidder supplied GIS Breaker.
2. The limit for inrush current for switching of Transformer by CSD shall be 1.0 p.u. of rated current of transformer after fine tuning of CSD settings during pre-commissioning checks. For site acceptance of CSD, during online CSD test after fine tuning inrush current should be less than 1.0 P.U. of rated current in five consecutive operations.
3. All 400kV Circuit Breaker control schematics shall be finalized in such a way, that it may operate with or without CSD by using a suitable selector switch irrespective of whether circuit breakers to be supplied are envisaged along with CSD or not as per bid price schedules.
4. Complete interfacing with GIS and CSD shall be in bidder's scope. Any additional item like transducer, contact multiplication relay, switches, special/screened cables, modification hardwired, modification in schematics (if any) required for interfacing and for complying to the technical specification requirement shall be in bidder's scope and shall be included in quoted price. No price implication for the same shall be

entertained during detailed engineering.

5. All wiring necessary for interface of GIS/ CRP with bidder supplied CSD is also deemed to be included in the scope of bidder. Cables, lugs, ties etc required for connection of CSD in existing relay panel is deemed to be included in bidder's scope.
6. Supervision of Erection only and testing & Commissioning of CSD shall be in bidder's scope.
7. The CSD should have display facility at the front for the display of settings and measured values. In case where CSD does not have complete display facility for settings and measured values, bidder to supply one number laptop PC with pre-installed, licensed software for each site. Cost of the same shall be deemed included in offer.
8. Special cables (i.e., screened/ FO cable) other than 1100V LT Power & Control Cables required for CB / CSD / Relay Panel interfacing shall be in bidder's scope. Mode of measurement for special cable shall be cable-trench running length from GIS to CSD/ Relay panel. Total requirement of special cable qty. is to be estimated & supplied by bidder based on no. of runs etc.

[6] TECHNICAL QUALIFYING REQUIREMENTS: Please refer following attached document for qualification criteria, Bidder to submit complete supporting documents required for technical qualifying requirement along with the bid

- **Annexure_Technical_PQR**

[7] TYPE TESTING, INSPECTION, TESTING & INSPECTION CERTIFICATE

Please refer Section-2 and Section-3 of technical specification for the details of type test requirement.

The type tests shall be carried out at reputed testing laboratory, the tests must have been carried out during last 15 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.

Type test certificates to this effect shall be enclosed with the Bid.

All equipment being supplied shall conform to type tests as per technical specification and shall be subject to routine tests in accordance with requirements stipulated under respective sections.

The reports for all type tests as per technical specification shall be furnished by the bidder along with equipment / material drawings. However, type test reports of similar equipment / material already accepted in CUSTOMER (in the projects similar to present project) shall be applicable for all projects with similar requirement. The type tests conducted earlier should have either been conducted in accredited laboratory (accredited based on ISO / IEC Guide 25 / 17025 or EN 45001 by the national accreditation body of the country where laboratory is located) or witnessed by CUSTOMER/representative authorized by CUSTOMER/representative of Utility /representative of accredited test lab/ representative of The National Accreditation Board for Certification Bodies (NABCB) certified agency shall also be acceptable.

The validity of the type test report shall be in accordance with the latest CEA guidelines, which shall prevail for validity over any other provisions of the Technical Specification.

The type test reports submitted shall be of the tests conducted within last 15* (Fifteen) years from the originally scheduled date of bid opening of tender of CUSTOMER i.e. **17 October 2025**. In case the test reports are of the test conducted earlier than 15* (Fifteen) years from the original date

of technical bid opening of tender (Tender of CUSTOMER), the contractor shall repeat these test(s) at no extra cost to BHEL / CUSTOMER.

Further, in the event of any discrepancy in the test reports i.e. any test report not acceptable due to any design/manufacturing changes or due to non-compliance with the requirement stipulated in the Technical Specification or any/all type tests not carried out, same shall be carried out without any additional cost and delivery implication to BHEL/CUSTOMER.

The Bidder shall intimate BHEL with the detailed program about the type tests at least two (2) weeks in advance in case of domestic supplies & six (6) weeks in advance in case of foreign supplies.

Note – Type test report shall be reviewed for approval in detailed engineering stage only. However, for evaluation purpose, the test reports are to be submitted along with the technical bid.

[8] INFORMATION TO BE SUBMITTED WITH TECHNICAL BID

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.

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ANNEXURE: BOQ_400KVGIS_Khorlochhu **REV.00, V3** **02-12-2025**

Sl. No.	Item Description	Unit	Qty.	Remarks
1.00	**SUPPLY- GIS: 400KV, 63KA FOR 3S, DOUBLE BUS SCHEME GAS INSULATED SWITCHGEAR (GIS) AS PER TS**			
1.01	400KV, 2000A, 63KA FOR 3S, SF6 GIS GENERATOR TRANSFORMER FEEDER BAY MODULE	SET	**4**	IN FULL COMPLIANCE WITH THE TECHNICAL SPECIFICATION, INCLUSIVE OF LCC, SF6 GAS, STRUCTURE, GIB WITHIN GIS HALL, HARDWARES & EARTHING MATERIALS ETC TO COMPLETE GIS SYSTEM
1.02	400KV, 2000A, 63KA FOR 3S, SF6 GIS ICT FEEDER BAY MODULE	SET	**1**	IN FULL COMPLIANCE WITH THE TECHNICAL SPECIFICATION, INCLUSIVE OF LCC, SF6 GAS, STRUCTURE, GIB WITHIN GIS HALL, HARDWARES & EARTHING MATERIALS ETC TO COMPLETE GIS SYSTEM
1.03	400KV, 2000A, 63KA FOR 3S, SF6 GIS REACTOR FEEDER BAY MODULE	SET	**1**	IN FULL COMPLIANCE WITH THE TECHNICAL SPECIFICATION, INCLUSIVE OF LCC, SF6 GAS, STRUCTURE, GIB WITHIN GIS HALL, HARDWARES & EARTHING MATERIALS ETC TO COMPLETE GIS SYSTEM
1.04	400KV, 2000A ,63KA FOR 3S, GIS LINE FEEDER BAY MODULE	SET	**2**	IN FULL COMPLIANCE WITH THE TECHNICAL SPECIFICATION, INCLUSIVE OF LCC, SF6 GAS, STRUCTURE, GIB WITHIN GIS HALL, HARDWARES & EARTHING MATERIALS ETC TO COMPLETE GIS SYSTEM
1.05	400KV, 2000A, 63KA FOR 3S, SF6 GIS BUS COUPLER BAY MODULE	SET	**1**	IN FULL COMPLIANCE WITH THE TECHNICAL SPECIFICATION, INCLUSIVE OF LCC, SF6 GAS, STRUCTURE, GIB WITHIN GIS HALL, HARDWARES & EARTHING MATERIALS ETC TO COMPLETE GIS SYSTEM
1.06	400KV, 63KA FOR 3S, SF6 BUS VT BAY MODULE INCLUDING DISCONNECTOR, EARTHSWDUC, INCLUDING MAIN BUS	SET	2	IN FULL COMPLIANCE WITH THE TECHNICAL SPECIFICATION, INCLUSIVE OF LCC IF REQUIRED SEPARATELY, SF6 GAS, STRUCTURE, HARDWARES & EARTHING MATERIALS ETC TO COMPLETE.
1.07	400 KV, 2000 A, 63 KA, 3S, SINGLE PHASE, SF_6 GIS MAIN BUSBAR. (MODE OF MEASUREMENT SHALL BE THE STRAIGHT LENGTH OF THE MAIN BUSBAR ALONG THE GIS HALL)	M	510	IN FULL COMPLIANCE WITH THE TECHNICAL SPECIFICATION, INCLUSIVE OF SF6 GAS, STRUCTURE, HARDWARES & EARTHING MATERIALS ETC TO COMPLETE.
1.08	400KV, 2000A, 63KA FOR 3S, SINGLE PHASE, SF6 GAS INSULATED BUS DUCT (GIB) **OUTSIDE GIS HALL**	M	150	REMARK: GIB WITHIN GIS HALL IS DEEMED INCLUSIVE OF RESPECTIVE BAY. SEPERATELY PAYABLE GIB MEASUREMENT SHALL BE RUNNING LENGTH FROM FINISHED FLOOR LEVEL UPTO SF6 TO OIL BUSHING. IN FULL COMPLIANCE WITH THE TECHNICAL SPECIFICATION, INCLUSIVE OF SF6 GAS, STRUCTURE, HARDWARES & EARTHING MATERIALS ETC TO COMPLETE.
1.09	MAIN BUS BAR END PIECE (INTERFACE) MODULES SET OF 3 PAHSE	SET	4	In full compliance with the Technical Specifications, including SF_6 gas, structures, hardware, earthing materials, and all other items required for completion. The contractor shall provide complete design details of the interface module, including cross-section, enclosure material, enclosure dimensions (inner and outer), flange diameter (inner and outer), conductor cross-section and connection arrangement, bolt spacing and dimensions, rated gas pressure, gasket details, and all other relevant parameters necessary for future extension of
1.10	400KV, 2000A, 63KA FOR 3S, SINGLE PHASE, SF6 TO CABLE CONNECTION MODULE	SET	9	IN FULL COMPLIANCE WITH THE TECHNICAL SPECIFICATION, INCLUSIVE OF SF6 GAS, STRUCTURE, HARDWARES & EARTHING MATERIALS ETC TO COMPLETE.
1.11	400KV, 2000A, 63KA FOR 3S, SINGLE PHASE, SF6 TO OIL CONNECTION MODULE	SET	15	IN FULL COMPLIANCE WITH THE TECHNICAL SPECIFICATION, INCLUSIVE OF SF6 GAS, STRUCTURE, HARDWARES & EARTHING MATERIALS ETC TO COMPLETE.
1.12	CONTROLLED SWITCHING DEVICE FOR 3-PH CIRCUIT BREAKER	SET	5	1 SET FOR 1 NUMBER 3 PHASE CIRCUIT BREAKER CONTROLLED SWITCHING AS PER TECHNICAL REQUIREMENT. SUPPLY OF THREE SET OF TRANSDUCER FOR GIS SUBSTATION IS DEEMED INCLUSIVE UNDER THE SCOPE OF SUPPLY.
1.13	Bay Control Unit (BCU)	SET	9	1 set shall be provided for each 3-phase Circuit Breaker Bay module, including all required interface materials within the GIS system and subsystems, such as the Bus VT module. The BCU shall be mounted in the LCC panel.
2.00	**SUPPLY- GIS: SPECIAL TOOLS AND TESTING & MAINTENANCE INSTRUMENTS (SCOPE OF SUPPLY & SERVICES ARE SUBJECT TO CHANGE)**			
2.01	ONLINE GAS MONITORING SYSTEM INCLUDING LOCAL MONITORING DISPLAY UNIT, HUMAN MACHINE INTERFACE (HMI) PANEL FOR GIS:	SET	1	**Temperature compensated density monitor shall be offered which shall contineously monitor the gas continuously.**
2.02	PORTABLE PARTIAL DISCHARGE MEASUREMENT TEST KIT WITH ALL NECESSARY ACCESSORIES, INDUSTRIAL GRADE LAPTOP AND LICENSED SOFTWARE	SET	1	
2.03	SF6 GAS TREATMENT PLANT FOR 400KV GIS STATION	SET	1	

ANNEXURE: BOQ_400KVGIS_Khorlochhu **REV.00, V3** **02-12-2025**

Sl. No.	Item Description	Unit	Qty.	Remarks
2.04	TWO-WHEEL SF6 GAS MAINTENANCE CART	SET	1	
2.05	SF6 GAS ANALYZER	SET	1	
2.06	SF6 GAS LEAKAGE DETECTOR	SET	2	
2.07	SUPPLY OF DEW POINT METER	SET	1	
2.08	Time Recorders For Breaker	SET	1	
2.09	Time Recorders For Isolators	SET	1	
2.1	Instrument For Automatic And Continuous Gas Monitoring In GIS Hall	SET	2	

BOQ_400KVGIS_Khorlochhu REV.00, V3 02-12-2025

Sl. No.	MANDATORY SPARES - ITEM DESCRIPTION	Unit	Qty.
	GENERAL ITEM		
3.101	SF6 TO CABLE CONNECTION MODULE (GIS PORTION) Cable Connection Enclosure with the main Circuit - (Set of each type and rating)	Set	1
3.102	SF6 TO OIL CONNECTION MODULE (GIS PORTION) for bushing of Transformer/Reactor as applicable of each rating with the main circuit (Set of each type and rating)	Set	1
3.103	SF6 gas Pressure Relief Devices of each type along with O-rings (Set of each type and rating)	Set	2
3.104	SF6 Pressure gauge cum switch OR Density monitors and pressure switch (as applicable) Percentage of Total population (max 5 min 1)	Percentage	5
3.105	Coupling device of each type for pressure gauge cum switch for connecting Gas handling plant (Set of each type and rating)	Set	2
3.106	Rubber Gaskets, O-Rings and Seals for SF6 gas of each type (Set of each type and rating)	Set	3
3.107	Molecular filter for SF6 gas with filter bags, Percentage of Total weight	Percentage	5
3.108	All types of Control Valves for SF6 gas of each type (Set of 1 number of each type and rating)	set	3
3.109	Spare SF6 Gas, Percentage of Total gas quantity by weight	Percentage	20
3.110	Additional (10%) supply of SF6 Gas complete with containers and monitoring equipment for use during the warranty period. (gas quantity by weight)	Percentage	10
3.111	Locking device to keep the Dis-connectors (Isolators) and Earthing switches in close or open position (Set of 1 number of each type and rating)	set	3
3.112	Spares for local control cabinet including MCB, Fuses, Timers, Aux. relays, Contactor, Push Buttons, Switches, Lamps, Annunciation Windows etc. (Set of each type and rating)	Set	2
3.113	UHF PD Sensors of each type, Percentage of Total population (max 5 Nos and min. 1 No.)	Percentage	5
3.114	Support Insulator/Gas Barrier of each type along with associated contacts and shields (Set of 1 number of each type and rating)	set	5
3.115	SF6 Gas Filling Kit (Hose, valve adaptors, regulator) complete set	Set	1
3.116	Gas Sampling Port Adapter and Gas Filters (Moisture/Particle) complete set	Set	1
3.117	Partial Discharge Sensors (UHF/VHF) of Online condition monitoring complete set	Set	1
3.118	GIS Alignment Tool Kit - OEM-specific torque tools, alignment jigs FULL KIT SET	Set	1
3.119	Controlled Switching Device along with Transducers, Sensors, Contactors, Switches etc. (Set of each type and rating)	Set	1
	CIRCUIT BREAKER		
3.201	Complete Circuit Breaker (1 phase unit) of each type & rating (complete with interrupter, main circuit, enclosure and Marshalling Box) (Set of each type and rating)	Set	1
3.202	Trip coil assembly with resistor as applicable (Set of each type and rating)	Set	2
3.203	Closing coil assembly with resistor as applicable (Set of each type and rating)	Set	2
3.204	CIRCUIT BREAKER: Grading Capacitor (Nos.)	Nos.	3

BOQ_400KVGIS_Khorlochhu REV.00, V3 02-12-2025

Sl. No.	MANDATORY SPARES - ITEM DESCRIPTION	Unit	Qty.
3.205	CIRCUIT BREAKER: Rubber gaskets, O-rings and seals (Set of each type and rating)	Set	1
3.206	CIRCUIT BREAKER: Molecular filter (Nos.)	Nos.	2
3.207	CIRCUIT BREAKER: Density/Pressure monitoring systems (Nos.)	Nos.	1
3.208	CIRCUIT BREAKER: SF6 Gas (for CB), Percentage of Total used quantity in substation	Percentage	15
3.209	CIRCUIT BREAKER: Relays, Power contactors, push buttons, timers & MCBs etc. of each type and rating (Set of each type and	Set	1
3.210	CIRCUIT BREAKER: Auxiliary switch assembly (Set of each type and rating)	Set	2
3.211	CIRCUIT BREAKER: Operation Counter (Set of each type and	Set	2
3.212	CIRCUIT BREAKER: Window scope / Observing window (Set of each type and rating)	Set	2
3.213	CIRCUIT BREAKER: LOTO arrangement provision (Set of each type and rating)	Set	1
	For Hydraulic Operated Mechanism, if applicable		
3.301	Hydraulic operating mechanism with drive motor of each type (Set of each type and rating)	Set	1
3.302	Ferrules, joints and couplings of each type (For Hydraulic Operated Mechanism, if applicable) (Set of each type and rating)	Set	1
3.303	Hydraulic filter of each type (For Hydraulic Operated Mechanism, if applicable) (Set of each type and rating)	Set	1
3.304	Hose pipe of each type (For Hydraulic Operated Mechanism, if applicable) (Set of each type and rating)	Set	1
3.305	N2 Accumulator of each type (For Hydraulic Operated Mechanism, if applicable) (Set of each type and rating)	Set	1
3.306	Valves of each type including Safety valve (For Hydraulic Operated Mechanism, if applicable) (Set of each type and rating)	Set	1
3.307	Valves of each type (For Hydraulic Operated Mechanism, if applicable) (Set of each type and rating)	Set	1
3.308	Pipe length (copper & steel) of each size & type (For Hydraulic Operated Mechanism, if applicable) (Set of each type and rating)	Set	1
3.309	Pressure switches of each type (Set of each type and rating)	Set	1
3.310	Pressure gauge with coupling device of each type (For Hydraulic Operated Mechanism, if applicable) (Set of each type and rating)	Set	1
3.311	Hydraulic oil (For Hydraulic Operated Mechanism, if applicable), Percentage of total qty. used	Percentage	20
3.312	Pressure Relief Device of each type (For Hydraulic Operated Mechanism, if applicable) (Set of each type and rating)	Set	1
3.313	Spring Charging Motor with Limit switch (For Hydraulic Operated Mechanism, if applicable) (Set of 1 number of each type and	set	2
	For Spring Operated Mechanism, if applicable		
3.401	Complete Spring Operating Mechanism including charging mechanism etc. of each type (Set of each type and rating)	Set	1
3.402	Spring Charging Motor (Set of 1 number of each type and rating)	set	2
	ISOLATORS		
3.501	Complete set of 3 nos. of single phase / one 3-phase isolator of each type (Set of each type and rating)	Set	1
3.502	3 No. of single phase / one no of 3-phase Maintenance Earthing switch of each type (Set of each type and rating)	Set	1
3.503	3 No. of single phase / one no of 3-phase Fast Earthing switch of each type (if applicable) (Set of each type and rating)	Set	1

BOQ_400KVGIS_Khorlochhu REV.00, V3 02-12-2025

Sl. No.	MANDATORY SPARES - ITEM DESCRIPTION	Unit	Qty.
3.504	Copper contact fingers for isolator male & female contact along with corona shield – for one complete (3 phase) isolator (Set of each type and rating)	Set	1
3.505	Copper contact fingers for Maintenance Earthing switch male & female contacts along with corona shield (Set of each type and	Set	1
3.506	Isolator Arms with finger contacts and current carrying assembly complete set	Set	1
3.507	Copper contact fingers for Fast Earthing switch male & female contacts along with corona shield (if applicable) (Set of each type and rating)	Set	1
3.508	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	Set	1
3.509	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) Maintenance Earth switch	Set	1
3.510	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) Fast Acting Earth switch	Set	1
3.511	Limit switch and Aux. Switches for complete 3 phase equipment - For Isolator	Set	2
3.512	Limit switch and Aux. Switches for complete 3 phase equipment - For Maintenance Earth switch	Set	2
3.513	Limit switch and Aux. Switches for complete 3 phase equipment - For Fast Earthing Switch (if applicable)	Set	2
3.514	Drive Mechanism - For Isolator (Set of each type and rating)	Set	1
3.515	Drive Mechanism - For Maintenance Earth switch (Set of each type and rating)	Set	1
3.516	Drive Mechanism - For Fast Earthing Switch (if applicable) (Set of each type and rating)	Set	1
3.517	Motor for Drive Mechanism - For Isolator (Set of 1 number of each type and rating)	set	3
3.518	Motor for Drive Mechanism - For Maintenance Earth switch (Set of 1 number of each type and rating)	set	3
3.519	Motor for Drive Mechanism - For Fast Earthing Switch (if applicable) (Set of 1 number of each type and rating)	set	3
3.520	Mechanical Interlock Devices interlock for earth switch and isolator (Set of each type and rating)	Set	1
3.521	LOTO arrangement provision for Isolator (Set of each type and	Set	1
	CURRENT TRANSFORMER		
3.601	Complete CT with Terminal connector & structure of each type and rating with enclosure to enable replacement of any type/ rating of CT by spare	Set	1
3.602	Primary Terminal Bushing of CURRENT TRANSFORMER complete	Set	2
	VOLTAGE TRANSFORMER		

BOQ_400KVGIS_Khorlochhu REV.00, V3 02-12-2025

Sl. No.	MANDATORY SPARES - ITEM DESCRIPTION	Unit	Qty.
3.700	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)	Set	1
	SURGE ARRESTOR		
3.810	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)	Set	1
3.820	Surge counter/ monitor of each rating and type for SURGE ARRESTOR (Set of each type and rating)	Set	1
	ADDITIONAL SPARES FOR TOOLS		
3.910	Tool For Lamp In Local Panel	Nos.	2
3.920	Special Gas Mask For GIS Maintenance No 2 No	Nos.	2
3.930	Display Unit (of HMI panel for GIS)	Nos.	1

BOQ_400KVGIS_Khorlochhu **REV.00, V3** **02-12-2025**

Sl. No.	Item Description	Unit	Qty.	Remarks
4.0	**SPARES- GIS: OPTIONAL ITEM / REFERENCE UNIT PRICE FOR ADDITION / DELETION OF SUPPLY ITEMS** (Unit Prices of Individual Equipment included here or in manadatory spares are required for any Addition/Deletion of Equipment and replacement of damaged items/ additional requirements =. Bidder to ensure that the unit prices have a logical relationship with prices of assemblies in main items. Quoting for unit prices is mandatory and shall be considered for evaluation)			
4.01	SUPPLY- GIS: SPARES: 400KV, EXPANSION JOINT - 3 PHASE (ANY OF MAIN BUS / GIB)	Set	2	PRO RATA RATE SHALL BE APPLICABLE
4.02	SUPPLY- GIS: SPARES: 400KV, L-BEND (1 PHASE)	Set	1	1set= 1 nos. of ANY type and each rating.
4.03	SPARE FOR SF6 GAS TREATMENT PLANT - Vacuum Pump	Set	2	
4.04	SPARE FOR SF6 GAS TREATMENT PLANT - Nozzles, Hoses	Set	2	
4.05	SPARE FOR SF6 GAS TREATMENT PLANT - Compressors With Gauges, Valves, Filters, Driers & Controls With Necessary Spares	Set	2	
4.06	SPARE FOR TWO-WHEEL SF6 GAS MAINTENANCE CART - Vacuum Pump	Set	2	
4.07	SPARE FOR TWO-WHEEL SF6 GAS MAINTENANCE CART - Nozzles, Hoses	Set	2	
4.08	SPARE FOR TWO-WHEEL SF6 GAS MAINTENANCE CART - Compressors With Gauges, Valves, Filters, Driers & Controls With Necessary Spares	Set	2	

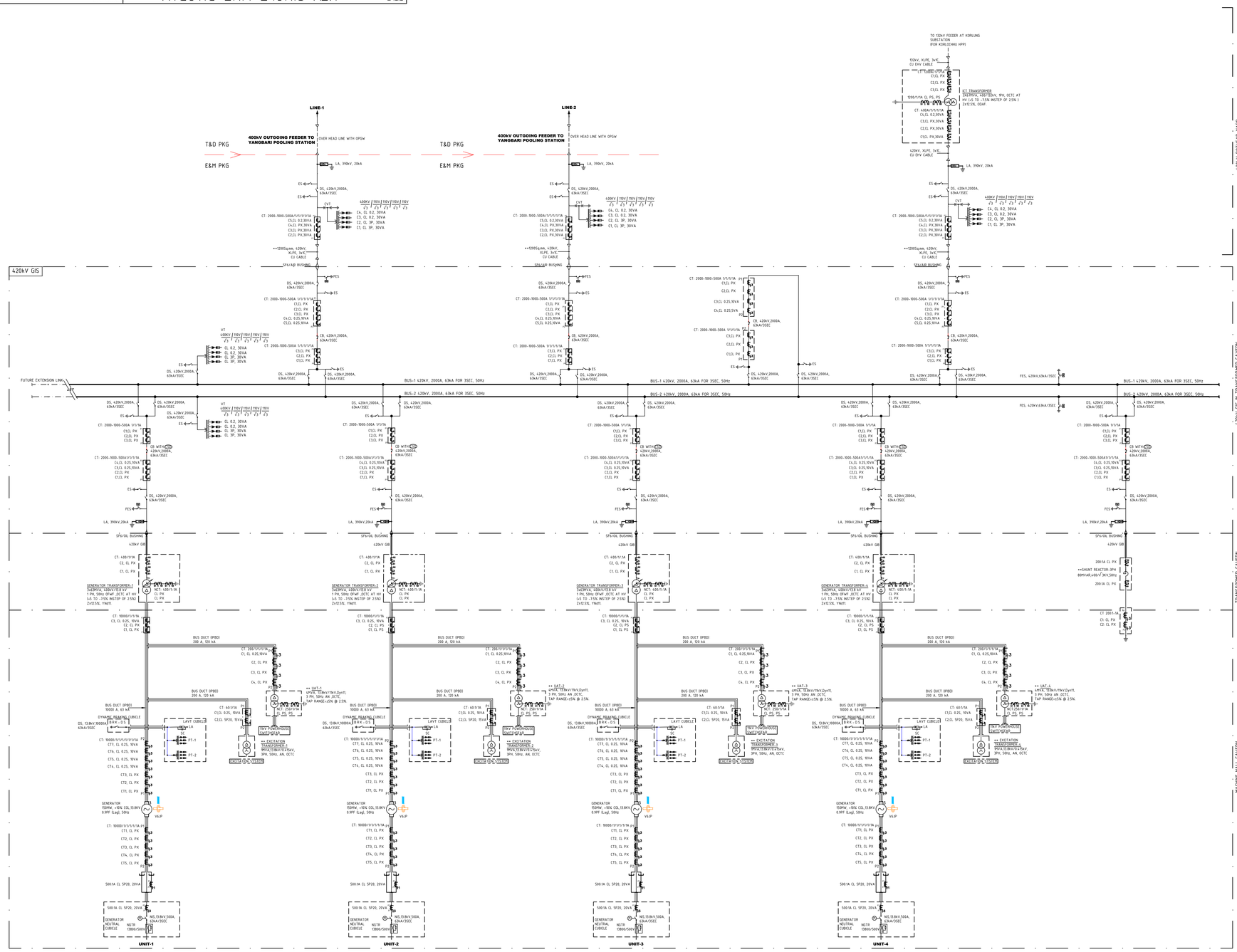
ANNEXURE: BOQ_400KVGIS_Khorlochhu **REV.00, V3** **02-12-2025**

Sl. No.	SERVICES DESCRIPTION	Unit	Quantity	Remarks
5.0	**SERVICES- GIS : 400KV, 63KA FOR 3S FOR IS, GAS INSULATED SWITCHGEAR (GIS) AS PER TS**			
5.01	SERVICES- 400KV GIS: SUPERVISION OF ERECTION OF GIS	Bays	9	Supervision of complete installation of the GIS system and its subsystems in full compliance with the Technical Specifications, including but not limited to the main bus, GIB within the GIS hall, LCC, earthing, structures, SF_6 gas filling works, cabling, and all related accessories and monitoring systems. This also includes verification of materials for proper on-site storage. The mode of measurement shall be per Circuit Breaker Bay. [Remark: GIS Bus Duct and SF_6-to-Oil, SF_6-to-Air, and SF_6-to-Cable connections are covered under separate BOQ line
5.02	SERVICES- 400KV GIS: SUPERVISION OF ERECTION OF GAS INSULATED BUS DUCT 1 PHASE (OUTSIDE GIS HALL)	MTR	150	Supervision of erection of GIB (outside GIS hall) complete in all respects as per the Technical Specifications. This item also covers earthing, SF_6 gas filling works, internal cabling with tray work, and associated structural works.
5.03	SERVICES- 400KV GIS: SUPERVISION OF ERECTION OF SINGLE PHASE, SF6 TO CABLE CONNECTION MODULE	SET	9	Supervision of erection of GIB (outside GIS hall) complete in all respects as per the Technical Specifications. This item also covers earthing, SF_6 gas filling works, internal cabling with tray work, and associated structural works.
5.04	SERVICES- 400KV GIS: SUPERVISION OF ERECTION- 400KV, SINGLE PHASE, SF6 TO OIL CONNECTION MODULE	SET	15	Supervision of erection of GIB (outside GIS hall) complete in all respects as per the Technical Specifications. This item also covers earthing, SF_6 gas filling works, internal cabling with tray work, and associated structural works.
5.05	SERVICES- 400KV GIS: TESTING & COMMISSIONING OF GIS	Bays	9	Testing and commissioning of the GIS system and its subsystems in full compliance with the Technical Specifications, including but not limited to the main bus, GIB within GIS Hall, LCC, and associated systems. All testing instruments, kits, tools, and plants (T&P), SF6 service cart, shall be arranged by the bidder on a returnable basis. Please refer to the relevant sections of the Technical Specifications for further details. [Remark: GIS Bus Duct outside the GIS hall and SF_6-to-Air/Oil/Cable bushings (as applicable) are covered under
5.06	SERVICES- 400KV GIS : TESTING & COMMISSIONING OF OF GAS INSULATED BUS DUCT 1 PHASE	MTR	150	Testing and commissioning of GIB (outside GIS hall) complete in all respects as per the Technical Specifications. All special testing instruments, kits, tools, and plants (T&P) shall be arranged by the bidder on a returnable basis. Please refer to the relevant sections of the Technical Specifications for further details.
5.07	SERVICES- 400KV, SINGLE PHASE, SF6 TO CABLE CONNECTION MODULE, TESTING & COMMISSIONING OF	SET	9	Testing and commissioning complete in all respects as per the Technical Specifications. All special testing instruments, kits, tools, and plants (T&P) shall be arranged by the bidder on a returnable basis. Please refer to the relevant sections of the Technical Specifications for further details.
5.08	SERVICES- 400KV, SINGLE PHASE, SF6 TO OIL BUSHING: TESTING & COMMISSIONING	SET	15	Testing and commissioning complete in all respects as per the Technical Specifications. All special testing instruments, kits, tools, and plants (T&P) shall be arranged by the bidder on a returnable basis. Please refer to the relevant sections of the Technical Specifications for further details.

Sl. No.	SERVICES DESCRIPTION	Unit	Quantity	Remarks
5.09	SERVICES- 400KV GIS : FINAL SUCCESSFUL HV/ POWER FREQUENCY TESTING OF GIS INCLUDING ARRANGING OF HV TEST KIT ALONG WITH OPERATOR	Bays	9	Carrying out successful HV/Power Frequency Testing of the complete GIS and its subsystems as per IEC requirements. Arrangement of the HV test kit with operator (on a returnable basis) shall be in the bidder's scope. This includes all charges for the HV test kit, operator, accessories, and tools required for the completion of HV testing. The quoted price shall cover all GIS bays, including the main bus, GIB, SAB/SOB/SF_6-to-Cable connections, and other common items as per the Technical Specifications, complete in all respects. Mobilization and demobilization of the HV test kit shall be considered once under this BOQ item. In case additional mobilization/demobilization is required for reasons not
5.10	SERVICES- ONLINE GAS MONITORING SYSTEM INCLUDING LOCAL MONITORING DISPLAY UNIT, HMI PANEL FOR GIS: SUPERVISION OF INSTALLATION, TESTING & COMMISSIONING	SET	1	Supervision of Installation, Testing & commissioning complete as per TS in all respect. All the special testing instruments, kits, T&P etc. are to be arranged by bidder on returnable basis. Please refer relevant section of technical specification for details.
5.11	SERVICES- 400KV GIS : INSULATION CO-ORDINATION STUDIES FOR GIS SYSTEM	LOT	1	1 Lot means Complete study report as per technical specification, Including VFTO report.
5.12	SERVICES- 400KV GIS : TRAINING FOR GIS AT MANUFACTURER WORKS & DESIGN OFFICE	DAY	8	In 2 batch of 4 days each for batch size of owner's 3 Engineers, 3 Technicians + 1 BHEL engineer in each batch.
6.0	**SERVICES- GIS : REFERENCE UNIT PRICE FOR ADDITION / DELETION OF SERVICES:** (UNIT PRICES OF INDIVIDUAL SERVICES INCLUDED HERE ARE REQUIRED FOR ANY ADDITION/DELETION OF EQUIPMENT AND REPLACEMENT OF DAMAGED ITEMS. VENDOR TO ENSURE THAT THE UNIT PRICES HAVE A LOGICAL RELATIONSHIP WITH PRICES OF ASSEMBLIES IN MAIN ITEMS. QUOTING FOR UNIT PRICES IS MANDATORY AND SHALL BE CONSIDERED FOR EVALUATION)			
6.01	SERVICES- 400KV GIS: REF. UNIT PRICE OF GIS INDIVIDUAL ITEM/ EQUIPMENT - SERVICES FOR SUPERVISION OF ERECTION OF GIS	MANDAY	10	Charges for repetition of services - (if required due to reasons not attributed to the bidder) This item will be executed only if repetition of services is required by BHEL.
6.02	SERVICES- 400KV GIS: REF. UNIT PRICE OF GIS INDIVIDUAL ITEM/ EQUIPMENT - SERVICES FOR TESTING & COMMISSIONING OF GIS	MANDAY	10	Charges for repetition of services - (if required due to reasons not attributed to the bidder) This item will be executed only if repetition of services is required by BHEL.
	DEMOBILIZATION AND REMOBILIZATION CHARGES			
6.03	SERVICES- 400KV GIS: DEMOBILIZATION AND REMOBILIZATION CHARGES FOR GIS ERECTION SUPERVISION TEAM	Set	1	THIS BOQ ITEM SHALL BE PAYABLE IF REQUIRED FOR REASONS NOT ATTRIBUTABLE TO BIDDER.
6.04	SERVICES- 400KV GIS: DEMOBILIZATION AND REMOBILIZATION CHARGES FOR GIS TESTING & COMMISSIONING TEAM	Set	1	BOQ ITEM SHALL BE PAYABLE IF REQUIRED FOR REASONS NOT ATTRIBUTE TO BIDDER. HV TESTING IS NOT PART OF THIS ITEM.
6.05	SERVICES- 400KV GIS: DEMOBILIZATION & REMOBILIZATION CHARGES OF HV TEST KIT ALONG WITH OPERATOR	Lot	1	In this BOQ item, mobilization and demobilization chages for HV test kit is considered for second time or more , for reasons not attributable to bidder. HV testing charges shall be paid per bay basis as per main HV testing charge.

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

NOTE - CABLE CONNECTION MODULE AND SF6 TO OIL CONNECTION MODULE SHALL BE AS PER BPS. For Line and ICT, SF6 to Cable connection shall be provided

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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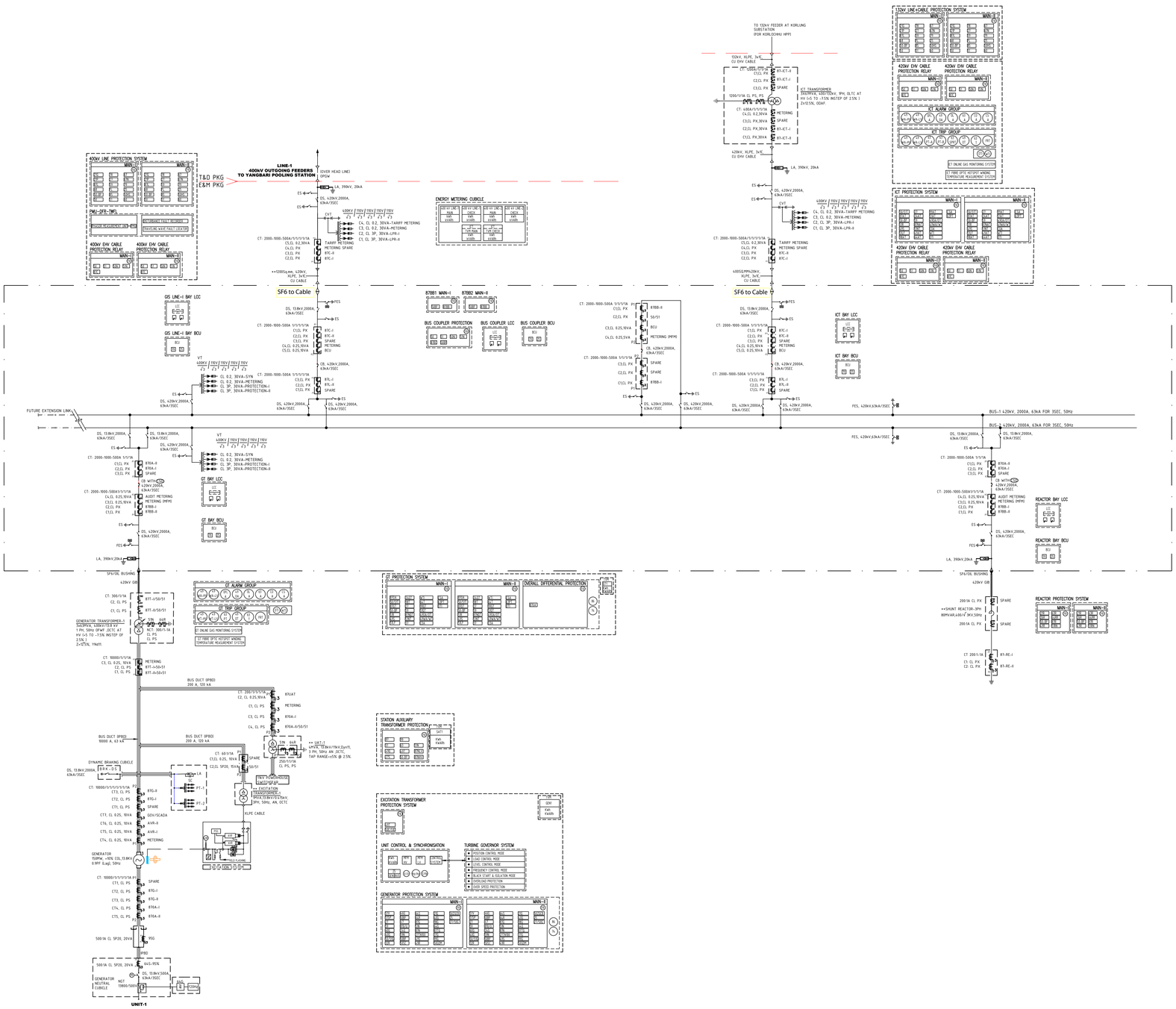
APPROV.	CIVIL	MECH.	INST.	ELEC.	STRL.	ARCH.	NATURE OF REVISION & DESCRIPTION	CHECKED	DRAWN	REV.	DATE
REVIEWED											

TITLE: METERING AND PROTECTION SYSTEM SINGLE LINE DIAGRAM

DWG NO KHPP-EL-PH-SLD-4006-AU-40002



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

PROTECTION SYSTEM LEGEND TABLE

ANSI CODE	GENERATOR PROTECTION DESCRIPTION
51V	51V -OVERCURRENT PROTECTION WITH VOLTAGE CONTROL
51SP G1	51SP- INSTANTANEOUS OR TIME-DELAYED OVERCURRENT PROTECTION
60G1	VOLTAGE BALANCE PROTECTION
40G	LOSS OF EXCITATION PROBLEM
FR	FAULT RECORDER
50/51G	INSTANTANEOUS OVERCURRENT PROTECTION/TIME-OVERCURRENT PROTECTION
32R	REVERSE POWER PROTECTION
46G	NEGATIVE PHASE SEQUENCE CURRENT PROTECTION.
50BF	BREAKER FAILURE PROTECTION
47	NEGATIVE SEQUENCE VOLTAGE PROTECTION
81O/U	UNDER/OVER FREQUENCY PROTECTION
24G	OVEREXCITATION PROTECTION
59N	NEUTRAL OVERVOLTAGE PROTECTION
27	UNDER VOLTAGE PROTECTION
59	OVER VOLTAGE PROTECTION
505C	SHORT-CIRCUIT PROTECTION
64S -95%	64S- 95% STATOR GROUND FAULT PROTECTION
64R	ROTOR EARTH FAULT PROTECTION
87G	87G- GENERATOR DIFFERENTIAL PROTECTION
51N	OVERCURRENT GROUND FAULT PROTECTION
87N	GROUND DIFFERENTIAL PROTECTION
27TN100	THIRD HARMONIC UNDER-VOLTAGE PROTECTION
49S	STATOR THERMAL OVERLOAD PROTECTION
49R	ROTOR THERMAL OVERLOAD PROTECTION
21G	GENERATOR BACKUP IMPEDENCE PROTECTION
40G	LOSS OF FIELD (EXCITATION) PROTECTION
98G	POLE SLIPPING PROTECTION
64G	STANDBY STATOR EARTH FAULT PROTECTION
87TG	INTER-TURN FAULT PROTECTION
37G	LOW-FORWARD POWER PROTECTION
99G	OVER-FLUXING PROTECTION FOR GENERATOR
50GDM	ACCIDENTAL BACK ENERGISATION PROTECTION
50ZGCB	GENERATOR CIRCUIT BREAKER FAILURE PROTECTION
25	SYNCHRONISING CHECK RELAY
27/50G	DEAD MACHINE PROTECTION
50-BF	BREAKER FAILURE PROTECTION
86	MASTER TRIP RELAY
74	TRIP CIRCUIT SUPERVISION
	GT PROTECTION DESCRIPTION
87OA	OVERALL DIFFERENTIAL PROTECTION
50/51T	INSTANTANEOUS AND TIME-OVERCURRENT PROTECTION
87GT	TRANSFORMER DIFFERENTIAL PROTECTION RELAY
50-BF	BREAKER FAILURE PROTECTION
51R	TIME OVERCURRENT PROTECTION
49S	THERMAL OVERLOAD PROTECTION
51LF	TIME OVERCURRENT PROTECTION SPECIFICALLY FOR LOW-FREQUENCY APPLICATIONS
24GT	VOLT PER HERTZ / OVER FLUXING PROTECTION
98T	TRANSFORMER BUSHING INSULATION
27	UNDER VOLTAGE PROTECTION
59	OVER VOLTAGE PROTECTION
87NGT	RESTRICTED EARTH FAULT PROTECTION FOR GENERATOR TRANSFORMER
51NT	TIME OVERCURRENT PROTECTION FOR THE NEUTRAL CIRCUIT
37	LOSS OF FIELD PROTECTION
49GT	THERMAL OVERLOAD PROTECTION, SPECIFICALLY FOR THE END TURNS OF STATOR WINDINGS
64T	GROUND FAULT PROTECTION.
99GT	OVER-FLUXING PROTECTION FOR GENERATOR TRANSFORMER
51GT	BACK- UP NON-DIRECTIONAL OVER-CURRENT PROTECTION IN ALL PHASES ON HV SIDE OF GENERATOR TRANSFORMER
490A/OT	OIL TEMPERATURE ALARM/OIL TEMPERATURE TRIP
49WA/WT	WINDING TEMPERATURE ALARM/WINDING TEMPERATURE TRIP
COA	COOLER TROUBLE ALARM RELAY
CSA	COOLER SUPPLY FAILURE ALARM
63PT	PRESSURE RELIEF DEVICE TRIP
OTI	OIL TEMPERATURE INDICATOR
WTI	WINDING TEMPERATURE INDICATOR
	BUSBAR & BUSCOUPLER PROTECTION DESCRIPTION
87BB	BUSBAR DIFFERENTIAL PROTECTION
50	INTANTANEOUS OVERCURRENT
51	TIME-DELAYED OVERCURRENT
50N	INTANTANEOUS EARTH FAULT
51N	TIME-DELAYED OVERCURRENT
50-BF	LINE BREAKER FAILURE
LCC	LOCAL CONTROL CABINET

ICT PROTECTION DESCRIPTION
INSTANTANEOUS AND TIME-OVERCURRENT PROTECTION
TRANSFORMER DIFFERENTIAL PROTECTION
BREAKER FAILURE PROTECTION
TIME OVERCURRENT PROTECTION
THERMAL OVERLOAD PROTECTION
GROUND FAULT PROTECTION.
TIME OVERCURRENT PROTECTION SPECIFICALLY FOR LOW-FREQUENCY APPLICATIONS
TRANSFORMER BUSHING INSULATION
UNDER VOLTAGE PROTECTION
OVER VOLTAGE PROTECTION
VOLT PER HERTZ / OVER FLUXING PROTECTION
RESTRICTED EARTH FAULT PROTECTION
TIME OVERCURRENT PROTECTION FOR THE NEUTRAL CIRCUIT
GROUND FAULT PROTECTION.
OVER-FLUXING PROTECTION FOR GENERATOR TRANSFORMER
BACK- UP NON-DIRECTIONAL OVER-CURRENT PROTECTION IN ALL PHASES ON HV SIDE OF GENERATOR TRANSFORMER
OIL TEMPERATURE ALARM/OIL TEMPERATURE TRIP
WINDING TEMPERATURE ALARM/WINDING TEMPERATURE TRIP
COOLER TROUBLE ALARM RELAY
COOLER SUPPLY FAILURE ALARM
PRESSURE RELIEF DEVICE TRIP
OIL TEMPERATURE INDICATOR
WINDING TEMPERATURE INDICATOR
SAT PROTECTION RELAY DESCRIPTION
DIFFERENTIAL CURRENT PROTECTION
RESTRICTED EARTH FAULT PROTECTION FOR LV WINDING
RESTRICTED EARTH FAULT PROTECTION FOR HV WINDING
UNDER VOLTAGE RELAY D91:F101
BACK-UP EARTH-FAULT PROTECTION
OVER-FLUXING PROTECTION
BUCHHOLZ PROTECTION
WINDING TEMPERATURE HIGH
OIL TEMPERATURE HIGH
BREAKER FAILURE PROTECTION
UNDER VOLTAGE RELAY
REACTOR BAY PROTECTION DESCRIPTION
REACTOR DISTANCE PROTECTION
REACTOR OIL TEMPERATURE RELAY
BREAKER FAILURE PROTECTION
REACTOR WINDING TEMPERATURE RELAY
REACTOR BUCHHOLZ RELAY
RESTRICTED E/F PROTECTION FOR BUS REACTOR
DIFFERENTIAL PROTECTION FOR BUS REACTOR
DIFFERENTIAL O/C & E/F PROTECTION
OVER HEAD LINE PROTECTION DESCRIPTION
GROUND DISTANCE
PHASE DISTANCE
LINE DIFFERENTIAL PROTECTION
BLOCKING RELAY / POWER SWING BLOCKING
LINE BREAKER FAILURE
PHASE ANGLE MEASURING OR OUT-OF-STEP PROTECTION
UNDER VOLTAGE PROTECTION
OVER VOLTAGE PROTECTION
FAULT LOCATOR
FAULT RECORDER
CARRIER OR PILOT-WIRE PROTECTION
DIRECTIONAL OVERCURRENT PROTECTION
NEUTRAL DIRECTIONAL OVERCURRENT PROTECTION
AUTO RECLOSER
SYNCHRONISM-CHECK
HIGH-SPEED OVER CURRENT
132/400KV XLPE , EHV CABLE PROTECTION DESCRIPTION
CABLE DIFFERENTIAL PROTECTION
INTANTANEOUS OVERCURRENT
TIME-DELAYED OVERCURRENT
INTANTANEOUS EARTH FAULT
TIME-DELAYED OVERCURRENT
LOCAL CONTROL CABINET

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

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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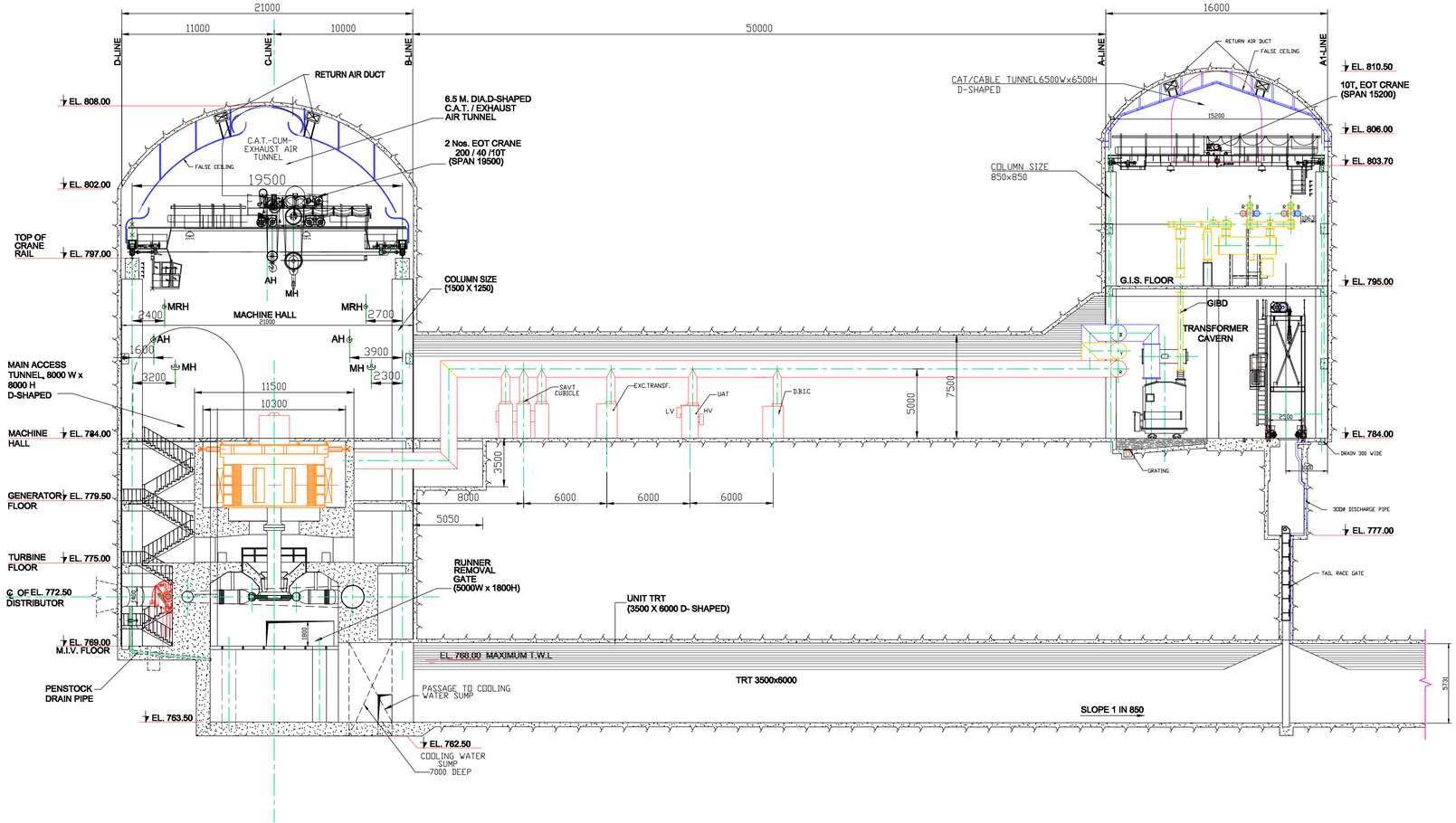
DESIGNED: JC / RKR	CHECKED: LGC	RECOMMENDED:
DRAWN : ZMT	APPROVED: PLN	

DWG No: KHPP–EL–PH–SLD–4006–AU–40002

SCALE: AS SHOWN	ISSUE P1	DATE: 20–JUN–2025	ORIGINAL PRINT SIZE: A1

TITLE: 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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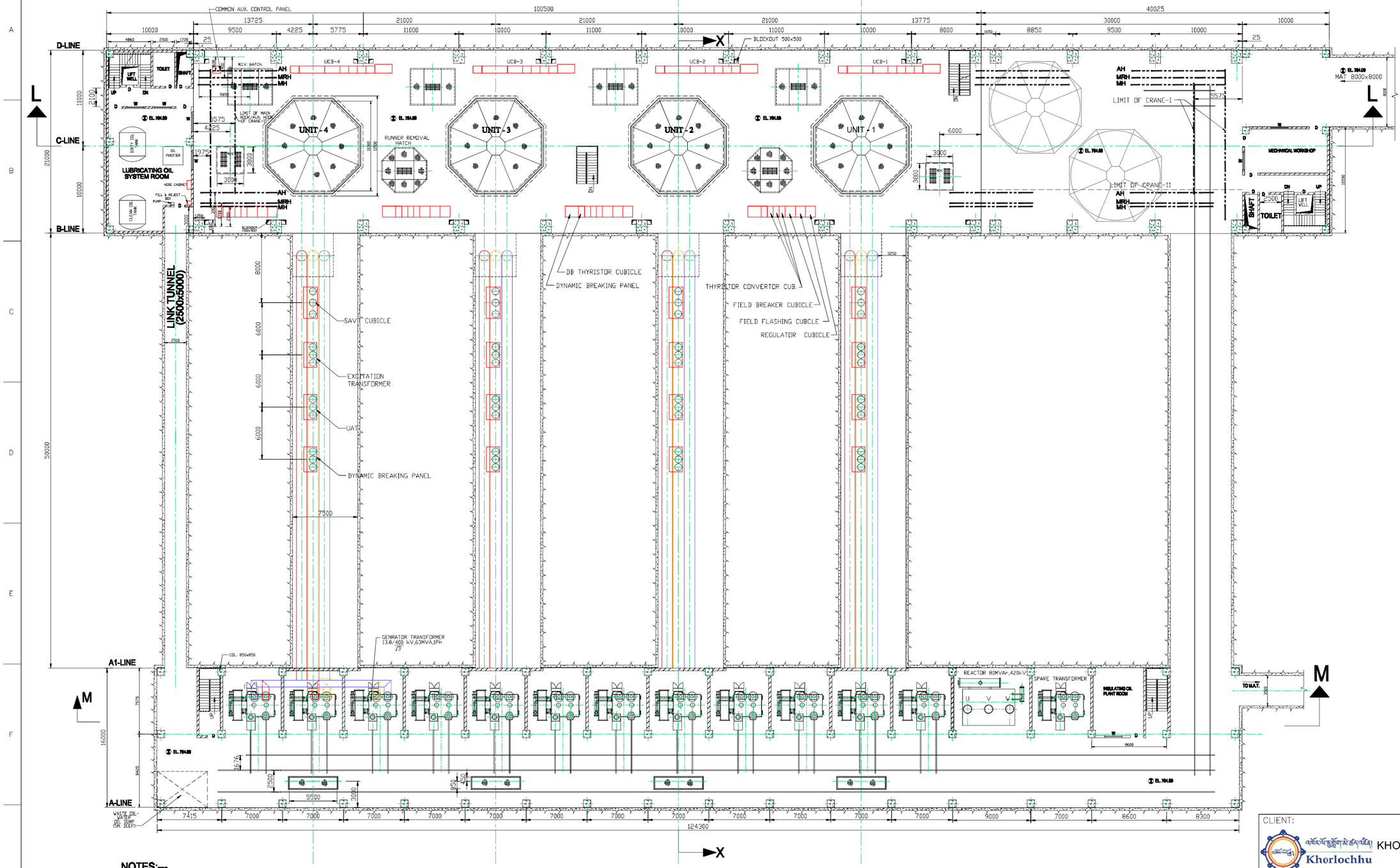
APPROV.	REVIEWED: CIVL	MECH.	INST.	ELEC.	STRL.	ARCH.	NATURE OF REVISION & DESCRIPTION	CHECKED	DRAWN	REV.	DATE

TITLE: LAYOUT OF MACHINE HALL, BUSDUCT GALLERIES AND TRANFORMER HALL (EL.784.00m)

DWG NO KHPP-ME-6017-GA-60001



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 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

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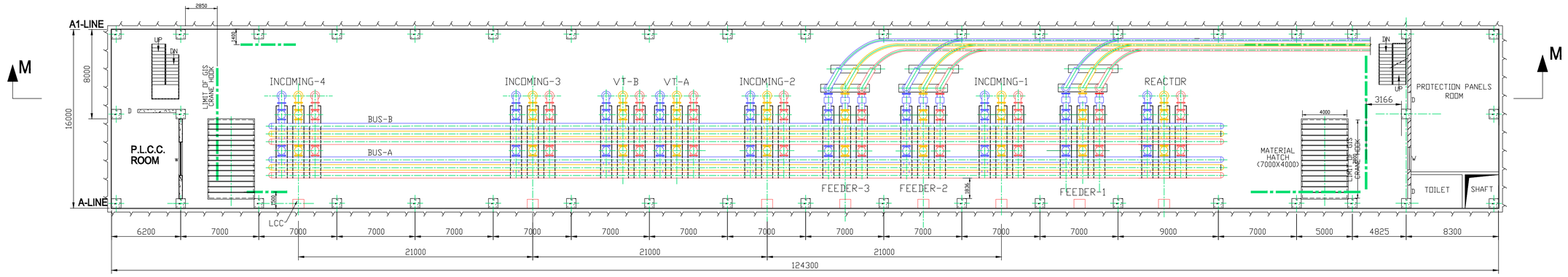
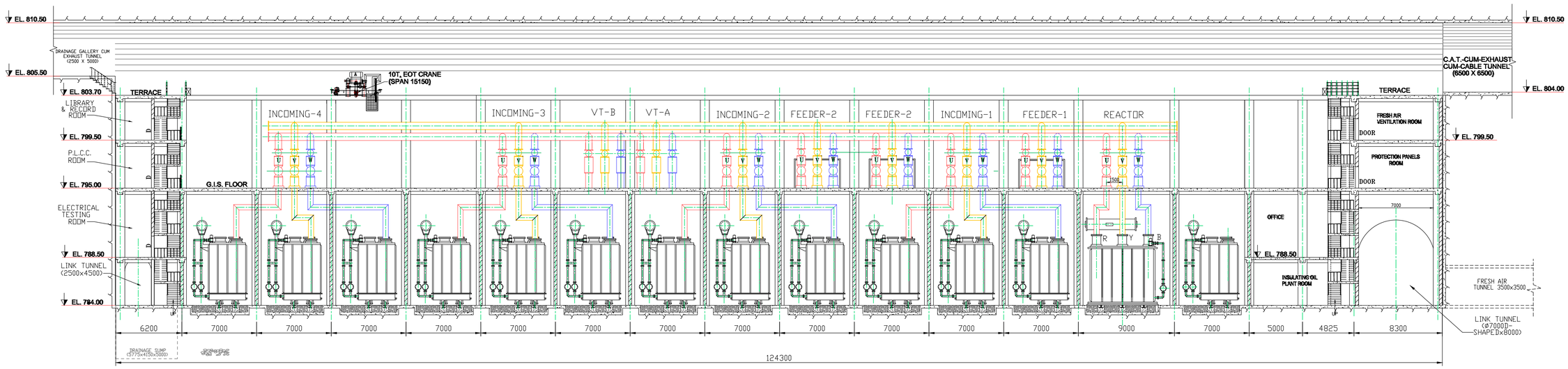
Khorlochhu Hydro Power Ltd.

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

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APPROV.	CIVIL	MECH.	INST.	ELEC.	STRL.	ARCH.	NATURE OF REVISION & DESCRIPTION	CHECKED	DRAWN	REV.	DATE
			REVIEWED								

Sl. No.	Clause Reference & Page	Addenda/Corrigenda
	Page 196 of 663	*Automatic & Manual control from* RTCC.
CHAPTER 9: 420 kV GAS INSULATED SWITCHGEAR		
102	Cl. No. 9.4.1 xvi) Page 220 of 663	The clause 9.4.1 xvi) is **"deleted".**
103	Cl. No. 9.4.1 vi) Page 220 of 663	Following sentences is added to the clause: *"Drawing and structural embedment shall be provided by E&M contractor while installation of embedment shall be carried by Civil."*
104	Cl. No. 9.4.1 xxv) Page 221 of 663	Clause No. 9.4.1 xxv) is amended as: *"Mounting of PD sensors will be as per latest applicable standard."*
105	Cl. No. 9.8.(xviii) Page 224 of 663	The clause is amended as: *"At each gas compartment, provisions shall be made for connecting to dew point meter. Supply of dew point meter is in the scope of bidder."*
106	Cl. No. 9.8.(xxiv) Page 225 of 663	Clause 9.8 xxiv) is **"deleted".**
107	Cl. No. 9.34 Page 257 of 663	Sl. No. **1.10, 1.12, 1.13, 1.16** of clause no. 9.34 are **"deleted"**
CHAPTER 10: 420 KV AND 145 KV XLPE CABLES		

Remark dated 02/12/2025 for this page: "As per Bidding Document or equivalents" shall be read as "As per Bidding Document or OEM's Standard Design."

Remark dated 02/12/2025 for this page: "As per Bidding Document or equivalents" shall be read as "As per Bidding Document or OEM's Standard Design."

Sl. No.	References	Description as per Tender Document	Queries from the Bidders	KHPL's Clarifications
214	Volume 4 Section – 7: PTS Chapter: 9 420 kV Gas Insulated Switchgear Clause 9.1/9.4 Page No. 218 of 663	The GIS will be connected to the main power transformers and 400kV XLPE cables will connect GIS to Pothead yard.	1. As per the layout and SLD, the GIS bus duct is located inside the Transformer and GIS cavern, with interconnections provided from GIS to GT and Shunt Reactor. There is no SF6-to-Air overhead line connection envisaged. Kindly confirm. 2. As per tender SLD we understand that SF6 to Oil termination shall be provided for transformer bays however for line bay & ICT bay SF6 to Air Bushing	XLPE cable termination will be as per OEM's site suitability.

Sl. No.	References	Description as per Tender Document	Queries from the Bidders	KHPL's Clarifications
			is shown kindly confirm for Line & ICT bay SF6 to Air termination shall be provided or cable termination (as mentioned in specification) shall be provided.	
215	Chapter 9, Cl. No. 9.3.(iv)	vii) Partial Discharge Monitoring devices (where applicable)	As per specification partial discharge monitoring mentioned and as per datasheet portable partial discharge monitoring mentioned kindly confirm exact requirement. However, we shall provide UHF compatible sensors, any other system is excluded from bidder scope of supply	Offline PD monitoring system will be supplied.
216	Volume 4 Section –7: Clause 9.4.1	xvii) All piping for SF6 gas and hydraulic operating mechanism including their fittings shall be made of copper, brass, or stainless steel	Please be informed that the 400 kV GIS circuit breakers are of spring-operated type instead of hydraulic operating mechanism, in line with the latest technology. Accordingly, piping for hydraulic operating mechanism is not applicable. Kindly confirm.	As per Bidding Document or equivalent.
217	Chapter 9, Cl. No. 9.4., 9.4.1 i)	420 kV Gas Insulated Switchgear	As per tender drawings we understand that GIS is indoor and same shall be offered.	Indoor GIS system to be installed inside the Underground Powerhouse.
218	Chapter 9, Cl. No. 9.4. 9.4.1 vi) General	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.	Noted however base frame of CB shall be provided, embedded steel shall be excluded from SEIL scope of supply.	Drawing and structural embedment shall be provided by E&M contractor while installation of embedment shall be carried out by Civil.
219	Chapter 9, Cl. No. 9.4. 9.4.1 x) General	Suitable glass window/telescopic port shall be provided in the circuit breaker	As per OEM Design Glass viewing window shall be provided for Disconnector and Earthing Switch (if the same is applicable for the OEM's design, as all OEM do not have viewports).	As per Bidding Document.
220	Chapter 9, Cl. No. 9.4., 9.4.1 xiv) General	The Bus and all current carrying parts shall be made of electrical grade Aluminum alloy.	The PTS specifies bus bar material as Aluminium Alloy, however the Data Sheet A1 (3.6) ask for Electrolytic copper. Bidder would like to inform that as	The Bus and all current carrying parts shall be as per bidding

Sl. No.	References	Description as per Tender Document	Queries from the Bidders	KHPL's Clarifications
			per OEM Standard proven design, practice and type tested Al alloy busbar will be provided. Kindly accept.	document or equivalent.
221	Chapter 9, Cl. No. 9.4. features, 9.4.1 xvi) General	A partition separating a compartment filled with insulating gas from a neighbouring compartment such as a cable box, filled with liquid, shall not show any leakage affecting the dielectric properties of the two media.	Bidder would like to inform that the same is not applicable. Offered cable housing are dry type cable termination. Kindly accept	Clause 9.4.1 xvi) is deleted.
222	Chapter 9, Cl. No. 9.4., 9.4.1 xxv) General	Gas barrier shall have PD Sensors	For offered GIS PD sensors are mounted on the flanges of GIS not on gas barriers selection of PD sensors location shall be as per OEMs standard practices.	Clause 9.4.1 xxv) amended as: *"Mounting of PD sensors will be as per latest applicable standard."*
223	Chapter 9, Cl. No. 9.4.1(xxvi),	Arching in compartment should not extend to neighbouring compartment. Each bay shall be sectionalized	Bidder would like to inform that for offered GIS, the busbar and busbar disconnector forms separate gas compartment. Thus, the chances of fault in busbar is nil. Thus, there shall be no internal arcs. Hence, it is not necessary to have gas barriers at end of each busbar. With this design required service continuity is complied. Thus, we request customer to keep it to the discretion of GIS OEM the decision of gas barriers in busbar. kindly accept.	As per Bidding Document or equivalent
224	Chapter 9, Cl. No. 9.7 ii) GIS Gas Section Page No. 222	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.		As per Bidding Document or equivalent
225	Chapter 9, Cl. No. 9.7.(v)	Compartmentalization shall be provided for circuit breaker, Busbar, Current transformer, Voltage transformer, Surge arrester	Current transformer being passive element shall be part or line side disconnector considering the technicalities of the substation. This is in line with OEMs standard practices.	As per Bidding Document or equivalent
226	Chapter 9, Cl. No. 9.8(v) x	Gas leakage detectors of an approved type shall be provided.	BIL is guaranteed as per IEC for minimum rated pressure.	As per Bidding Document.
227	Chapter 9, Cl. No. 9.8.(xvii)	If specified in Datasheet/ bill of materials, GIS shall be equipped with the remote online GAS monitoring system.	Bidder would like to inform that the GIS shall provide with analogue type gas density monitors for continuous gas monitoring on each gas tight compartment which shall wired up to LCC and LCC shall have the alarm supervision for checking the status, LCC is equipped with required hardware with hard logic interlocks complying to technical requirement. Cabling between LCC to CRP / SCADA shall be excluded from scope.	As per Clause 1.20.3 of GTS, the scope of cabling between or from LCC to SCADA/PLC system is in the scope of the bidder

Remark dated 02/12/2025 for this page: "As per Bidding Document or equivalents" shall be read as "As per Bidding Document or OEM's Standard Design."

Sl. No.	References	Description as per Tender Document	Queries from the Bidders	KHPL's Clarifications
			Further to add the only status of gas shall be seen SCADA. Kindly accept	
228	Chapter 9, Cl. No. 9.8.(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.	We do not envisage online moisture measurement. Gas is tested as per IEC in factory and at site also. Gas purity shall be measured at site also. However, from dew point meter the same shall be measured supply of dew point meter shall be excluded from SEIL GIS scope of supply.	Cl. No. 9.8.(xviii) amended as: *"At each gas compartment, provisions shall be made for connecting to dew point meter. Supply of dew point meter is in the scope of bidder."*
229	Chapter 9, Cl. No. 9.8.(xviii)	SF6 gas filters shall be as follows: a) For moisture (H2O): b) For gaseous arc by-products: c) For particles (generally dust residues) or solid arc by-products:	Same shall be as per OEMs standard practices online with standards	Confirmed. Refer amendment to the bid.
230	Chapter 9, Cl. No. 9.8.(xxiv	xxiv) The total design shall incorporate facilities for SF6 storage adjacent to the installed switchgear assembly.	Bidder would like to clarify that instead of storage facility, SF6 gas bottles shall be provided. Kindly accept.	Clause 9.8 xxiv) is deleted.
231	Chapter 9.13 SF6 Gas Monitoring devices Page No. 226	The devices shall be gas density or temperature compensated for gas pressure gauges electrically isolated and independently adjustable, dust proof and vibration resistant.	Bidder would like to clarify that temperature compensated density monitor shall be offered which shall monitor the gas continuously. Kindly accept Any other system is excluded from bidder's scope	Accepted, which is as per the Bidding Document
232	Chapter 9, Cl. No. 9.19.1 Circuit breaker (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.	Bidder would like to inform that as per OEM Standard proven design and practice single interrupter circuit breaker will be supplied and Same is type tested and globally accepted. However, Type test report will be provided for review during detail engg. stage. Kindly accept.	As per the bidding document or equivalent.
233	Chapter 9, Cl. No. 9.19.2 Page No. 230	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.	For offered GIS the X/R ratio is design and tested as per IEC 62271-209 and IEC 62271-100.	Accepted. However, it shall be as per the latest applicable IEC Standards.

Sl. No.	References	Description as per Tender Document	Queries from the Bidders	KHPL's Clarifications
234	Chapter 9, Cl. No. 9.19.3 Page No. 230	Closing/Opening Resistors/Reactors (where applicable)	Bidder would like to inform that same is not applicable for offered GIS System.	As per the latest applicable standards.
235	Chapter 9, Cl. No. 9.20 xix) 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.	Electrical Interlocks & pad locking arrangement shall be provided as per OEMs standard type tested design.	As per the bidding document and/or latest applicable standard.
236	Chapter 9, 9.21 ii) Voltage Transformers Page No. 237	ii) Voltage Transformers All Voltage Transformers shall conform to the applicable standards mentioned in Data Sheet A2 in general	1. Kindly clarify the exact requirement. 2. We shall refer VT parameters as mentioned in tender SLD only. 3. We shall offer CT VT parameters as per Tender SLD received only. Any changes in CT VT parameters other than offered may have time & price implications Kindly confirm	*Separate cores for metering and protections for the CTs and PTs are required.* For supply, SLD to be referred.
237	Volume 4: Section – 7: PTS CHAPTER 9: 420 kV GAS INSULATED SWITCHGEAR Clause 9.30.1 (vi)	**Routine Tests** 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.	Kindly note that acceptance criteria for partial discharge shall be in accordance with IEC:62271-203.	Acceptance of all Routine Tests will be as per IEC 62271-203
238	Volume 4: Section – 7: Clause 9.30.1 (vi)	c) Each enclosure & partition shall be tested to withstand twice rated internal operating pressure and test reports of the tests shall be furnished.	Kindly note that test pressure of ensures shall be in accordance with IEC:62271-203.	Test pressure shall be as per IEC 62271-203
239	Volume 4: Section – 7: PTS CHAPTER 9: 420 kV GAS INSULATED SWITCHGEAR Clause 9.30.1	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.	Kindly note that Insulator is bought out item for GIS manufacturers. Therefore, it is not feasible to perform bending test. However, test manufacture's test certificates tested in accordance with applicable standard shall be provided for review.	As per Bidding Document.

Sl. No.	References	Description as per Tender Document	Queries from the Bidders	KHPL's Clarifications
240	Volume 4 Section – 7: PTS Chapter: 9 420 kV Gas Insulated Switchgear Clause 9.30.2	The type tests shall be carried out at reputed testing laboratory; the tests must have been carried out during last 5 years.	As per the latest CEA (central electricity authority) guidelines, the type test validity requirement for GIS is 15 years (in place of the earlier 5 years). We kindly request you to allow the same for further consideration.	Validity of type test report will be as per latest CEA guidelines.
241	Volume 4 Section – 7: PTS Chapter: 9 420 kV Gas Insulated Switchgear Clause 9.30.2	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	Kindly request you to accept valid Type Test Reports in place of conducting Special Tests, as repetition of these tests will lead to additional time and cost implications for the project.	Performance of type test will be as per latest CEA guidelines.
242	Volume 4 Section – 7: PTS Chapter: 9 420 kV Gas Insulated Switchgear Clause 9.32	Material For Bus-Bar - Electrolytic COPPER	As per the practice of all reputed GIS manufacturers such as Toshiba, GE, Hitachi, and Hyosung, bus bar conductors are manufactured using aluminium instead of copper. All these OEMs have successfully type-tested GIS with aluminium conductors. We therefore request you to kindly accept aluminium conductor in place of copper	As per Bidding Document.
243	Volume 4 Section – 7: PTS Chapter: 9 420 kV Gas Insulated Switchgear Clause 9.32	Offline partial discharge monitoring (PDM) system by portable device considered-- YES	As per Clause 9.32, S. No. 3.21, offline PD monitoring (portable device) has been specified for consideration. However, in Clause 9.15, online PD monitoring has been mentioned. We have considered the provision of an offline PD monitoring device in line with the datasheet requirements. Kindly confirm.	Off-line PD Monitoring system shall be accepted.
244	Volume 4 Section – 7: PTS Chapter: 9 420 kV Gas Insulated Switchgear Clause 9.32	9.32 (3.21) Offline partial discharge monitoring (PDM) system by portable device considered-- YES 9.32 (10.1) P.D. Monitoring-ONLINE	The requirement mentioned at Clause 9.32, S. No. 3.21, and Clause 9.32, S. No. 10.1 appears to be contradictory with respect to PD monitoring. We request you to kindly confirm which type of PD monitoring (Online or Offline) shall be applicable.	Off-line PD Monitoring system shall be accepted.

Sl. No.	References	Description as per Tender Document	Queries from the Bidders	KHPL's Clarifications
245	Volume 4 Section – 7: PTS Chapter: 9 420 kV Gas Insulated Switchgear Clause 9.32	Employer's Specification	Please confirm the requirement. As per our understanding, this pertains to testing, and the test shall be performed on one bay of the GIS, which shall include CB, CT, Disconnector, Earth Switch, Gas Density Switch, etc., as applicable in line with the Inspection Test Plan (ITP).	As per Bidding Document.
246	Volume 4 Section – 7: PTS Clause 9.34	Mandatory Spares	The spares mentioned at S. No. 1.10, 1.12, 1.13, and 1.16 are not applicable for the 400 kV GIS system. We kindly request you to remove the same from the spare list.	Clause 9.34 is deleted.
247	Volume 4 Section – 7: PTS Chapter: 9 420 kV Gas Insulated Switchgear Clause 9.34	Mandatory Spares	The mandatory spares listed at S. No. 2.14 to 2.25 are not applicable for spring-charged operating mechanism circuit breakers. These spares pertain to hydraulic-operated mechanism CBs, whereas the latest technology being offered is of spring-charged type. We therefore request you to kindly remove these items from the mandatory spare list.	As per Bidding Document.
248	Volume 4 Section – 7: PTS Chapter: 9 420 kV Gas Insulated Switchgear Clause 9.34	Mandatory Spares	The mandatory spares listed at S. No. 3.4, 3.5, 3.6, 3.7, 3.24, 3.25 and 4.2 are not applicable for Gas Insulated Switchgear (GIS), as these items are relevant only to AIS type switchgear. We therefore request you to kindly remove these from the mandatory spare list.	As per Bidding Document.
249	Volume 4 Section – 7: PTS Chapter: 9 420 kV Gas Insulated Switchgear Clause 9.34	Mandatory Spares	The mandatory spares listed at S. No. 6.3 and 6.4 are not applicable for Gas Insulated Switchgear (GIS), as these items are relevant GT/reactor & Cable. We therefore request you to kindly remove these from the mandatory spare list	As per Bidding Document.
			important since LFTV cables are high-value items,	

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

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 co[illegible]nsulating gas from a neighboring compartment such as a ca[illegible]uid, shall not show any leakage affecting the dielectric properties of the two media.

The clause 9.4.1 xvi) is **"deleted".**

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.

Following sentences is added to the clause:
"Drawing and structural embedment shall be provided by E&M contractor while installation of embedment shall be carried by Civil."

xxiv) Each section shall be provided with necessary valves to allow evacuation and refill of gas without evacuation of any other section.

xxv) Clause No. 9.4.1 xxv) is amended as:
"Mounting of PD sensors will be as per latest applicable standard."

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

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.

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

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) The clause is amended as:
"At each gas compartment, provisions shall be made for connecting to dew point meter. Supply of dew point meter is in the scope of bidder."

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:

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.

Included in SPARE BPS

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

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.

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.

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.

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.

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.

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.

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.

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.

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

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

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.

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.

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.

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.

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.

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.

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

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

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

In GIS Hall, ref BPS

Returnable basis

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

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

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 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.

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.

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.

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.

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.

TESTING & MAINTENACE EQUIPMENT

Testing & Maintenance equipment shall be offered, as per relevant schedule of BPS.

1. **SF6 Gas leakage detector.**

The detector shall be portable, battery operated, hand held type and having a minimum SF6 gas leakage sensitivity of 5gm/year. The sensor shall be connected through a flexible wand for easy accessibility to joints, seals and couplings in GIS equipment and provided with a protection filter. The equipment shall have on/off switch & suitable indicating lamps/LEDs, variable pitch audible signal for leakage indication. The equipment shall have automatic zeroing of background signals suitable for detecting SF6 gas leakage in charged switchyard. The test kit shall be compatible for EMI/EMC environment as per IEC 1000.

2. **Gas filling and evacuating plant : (Gas Processing unit)**

- The plant necessary for filling and evacuating the SF6 gas in the switchgear shall be supplied to enable any maintenance work to be carried out. This shall include all the necessary gas cylinders for temporarily storing the evacuated SF6 gas. The capacity of the temporary storage facilities shall at least be sufficient for storing the maximum quantity of gas that could be removed from at least one phase of one complete bay (switchgear and associated equipment).
- Where any item of the filling and evacuating plant is of such a weight that it cannot easily be carried by maintenance personnel, it shall be provided with lifting hooks for lifting and moving with the overhead cranes.
- The minimum capacity parameters of evacuation plant will be as under :

Oil Free Suction (Recovery) Pump:	30 M^3/Hour
Compressor (Two Stage):	15 M^3/Hour
Oil Free Vacuum Pump:	100 M^3/Hour

- The evacuation equipment shall be provided with all the necessary pipes, couplings, flexible tubes and valves for coupling up to the switchgear for filling or evacuating all the gases.

Details of the filling and evacuating plant that will be supplied, as well as the description of the filling and evacuating procedures shall be furnished

3. **SF6 gas analyzer:**

The SF6 gas analyser should be of portable type and instruments shall have following features:

a. In-built calibration facility.
b. Sensitivity of the equipment shall not be affected by any atmospheric conditions like dust, humidity, heat, wind etc.

c. Equipment shall work on zero gas loss principle i.e. gas should be pumped back to the compartment after measurement without any exposure to the atmosphere.

d. Equipment shall be supplied with suitable regulator which can be used to connect SF6 cylinder if required.

e. Following acidic/impurities products should be detected as per IEC 60480 and IEC 60376

i) SF6 purity – Range: 0-100 % & Accuracy: +/- 2 deg

ii) Dew point - Range : -60 to +20 deg C & Accuracy: +/- 4 deg C

iii) SO2 - Range : 0-150 ppm & Accuracy : +/- 2 %

iv) HF - Range : 0-10ppm & Accuracy : +/- 10 %

f. Instrument should work on AC source as well as on rechargeable battery

g. Input pressure: upto 10 bar

h. It should be housed in a robust IP67 case with wheels

.4. Portable Partial Discharge(PD) monitoring system

- The equipment shall be used for detecting different types of defects in Gas Insulated Stations (GIS) such as Particles, Loose shields and Partial Discharges as well as for detection of Partial discharges in other types of equipment such as Cable Joints, CTs and PTs.
- It shall be capable for measuring PD in charged GIS environment as EHV which shall have bandwidth in order of 100 MHz–2GHz with possibility to select a wide range of intermediate bandwidths for best measurement results. The principle of operation shall be based on UHF principle of detection. The instrument should also be able to detect partial discharges in cable joints and terminations.
- Detection and measurement of PD and bouncing particles shall be displayed on built in large LCD display and the measurement shall be stored in the instrument and further downloadable to a PC for further analysis to locate actual source of PD such as free conducting particles, floating components, voids in spacers, particle on spacer surfaces etc. Software for display and diagnosis of PD signals and an expert software system for accurate interpretation of cause of PD shall also be supplied and installed by the contractor.
- The equipment shall meet the following requirements
    1. Measurement shall be possible in noisy environment.
    2. Stable reading shall be possible in presence of vibrations within complex GIS assemblies, which can produce signals similar to PD.
    3. Equipment should have necessary synchronizing circuits to obtain PD correlation with power cycle and power frequency.
    4. The equipment shall be battery operated with built-in-battery charger. It shall also be suitable for 230V AC/50 Hz input.

5. Measurement shall be possible in the charged switchyard in the presence of EMI/EMC. Supplier should have supplied similar detector for GIS application to other utilities. Performance certificate and the list of users shall be supplied along with the offer.
6. Instrument shall be supplied with standard accessories i.e., re-locatable sensors with mounting arrangements, connecting cables (duly screened) to sensors, Lap-top PC, diagnostic and expert interpretation software, carrying case, rechargeable battery pack with charger suitable for 230V AC, 50Hz supply connecting cables (duly screened) to view in storage.
7. The function of software shall be covering the following:
   a) Data recording, storage and retrieval in computer
   b) Data base analysis
   c) Template analysis for easy location of fault inside the GIS
   d) Evaluation of PD measurement i.e, Amplitude, Phase Synchronization etc.
   e) Evaluation of bouncing/loose particles with flight time and estimation on size of particle.
   f) Expert software system for accurate interpretation of cause of PD.
   g) Report generation.
8. To prove the suitability in charged switchyard condition, practical demonstration shall be conducted before acceptance.
9. Supplier shall have "Adequate after sales service" facility in India and shall provide the document in support of this.
10. Necessary training may be accorded to personnel to make use of the kit for locating PD sources inside the GIS
11. Instrument shall be robust and conform to relevant standard.

- **Calibration:** The UHF Couplers have to be first calibrated as per CIGRE Document No. 654 as part of factory acceptance tests to guarantee detection sensitivity of 5pC or better. The GIS of same design shall be used as test specimen during the coupler calibration. The pulse injection level determined through above factory calibration tests shall only be used as reference for site sensitivity checks during commissioning of PDM system. The data sheet/frequency response characteristics shall be submitted for reference.
- Pulse generator, same type as that of used during factory testing for UHF sensor sensitivity test shall be supplied as a standard accessory.

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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,

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.

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

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.

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.

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.

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

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.

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.

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.

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.

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

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:**

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.

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.

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

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,”

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.

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

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.

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.

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

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

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.

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.

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.

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.

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.

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.

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

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.

xiii) In case of discrepancies between data as required by Technical Specifications
and those stated in the Data Sheets, the Stringent Specifications take precedence.

2.9 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	

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 20°c, RCT (Ohms)		
a)	For Class TPS CTS per IEC		
	• Rated Symmetrical Short Circuit		
	• Current At 20°c		
	• 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

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:

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: