NEPAL ELECTRICITY AUTHORITY

(An Undertaking of Government of Nepal)

TRANSMISSION DIRECTORATE

HETAUDA-DHALKEBAR-INARUWA 400KV SUBSTATION EXPANSION PROJECT

BIDDING DOCUMENT
FOR

Procurement of Plant Design, Supply, Installation, Testing and Commissioning of 400 kV Hetauda and Inaruwa Substations

Single-Stage, Two-Envelope
Bidding Procedure

Issued on:	**………………….**
Issued to:	**………………….**
Invitation for Bids No.:	**HDI/ICB/GIS/HTD-INA**
ICB No.:	**HDI/ICB/GIS/HTD-INA**
Employer:	**Nepal Electricity Authority**
Country:	**Nepal**

VOLUME II OF III

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1.0 PROJECT DESCRIPTION AND SCOPE

1.1 GENERAL

The primary objective of Nepal Electricity Authority (NEA) is to generate, transmit and distribute adequate, reliable and affordable power by planning, constructing, operating and maintaining all generation, transmission and distribution facilities in Nepal's power system both interconnected and isolated.

Nepal Electricity Authority (NEA) is establishing 400 kV GIS Substation at Hetauda, Makawanpur District and at Inaruwa of Sunsari District of Nepal under 400 kV Hetauda-Dhalkebar-Inaruwa Substation Expansion Project. The above project is being implemented by Nepal Electricity Authority, Transmission Directorate, funded from Government of Nepal.

1.2 Associated Transmission system:

The following transmission lines are associated with substation:-

i. Dhalkebar – Hetauda 400 kV D/C Lines: 140 km (along with OPGW)

ii. Dhalkebar- Inaruwa 400 kV D/C Lines: 155 km (along with OPGW)

iii. Naubise-Hetauda 400 kV D/C Lines: 150 km (along with OPGW)

1.3 Intent of Specification

This specification covers design, engineering, manufacture, fabrication, testing at manufacturers works, delivery, unloading at site, storage, erection, testing and commissioning at site complete for the execution of substation works to establish 400kV GIS (new) & Extension of 220 kV AIS Substation at Hetauda and Inaruwa. Above package, also include (a) 4X167MVA, 1-phase, 400/√3/220/√3/33 KV Autotransformers and 1X50 MVAR, 400 kV Bus Shunt Reactor at Hetauda Substation (b) 3X315 MVA, 400/220/33kV Transformer and 1X50 MVAR, 400 kV Bus Shunt Reactor at Inaruwa substation. It is the intent of this specification to describe primary features, materials, and design & performance requirements and to establish minimum standards for the work. The specification is not intended to specify the complete details of various practices of manufactures/ bidders, but to specify the requirements with regard to performance, durability and satisfactory operation under the specified site conditions. The detailed scope of work is brought out in subsequent clauses of this section.

2.0 SCOPE

The scope of this specification covers the following:

2.1.1 Hetauda Substation

The specification includes design, engineering, manufacture, fabrication, testing at manufacturers works, supply & delivery, unloading at site, storage, erection, testing and commissioning at site of the complete 400 kV switchyard including indoor SF6 gas insulated metal enclosed switchgear (GIS), 400 kV GIS ducts for making connections with outdoor transformers, bus shunt reactors and 400 kV overhead lines, 400 kV outdoor equipment, extension of 220 kV under construction switchyard (AIS type), 220 kV outdoor equipment, Control & protection, Substation Automation System, communication System and other electrical and mechanical auxiliary systems, associated civil works, internal roads, drains, necessary buildings etc. as described below:

2.1.1.1 Construction of a new 400 kV (GIS)/220 kV (AIS) substation at Hetauda with the provision of following bays as per Single Line Diagram. (The SF6 Gas Insulated Switchgear (GIS) of one-and- a half Breaker Bus Scheme shall be 420 kV, 5000A, 50 kA short circuit rating for 1 sec. and involves installation of following number of Bays):

i. 400 kV GIS bays, 2 nos. to terminate one 400 kV D/C Quad Moose ACSR lines from Dhalkebar.

ii. 400 kV GIS bays, 2 nos. to terminate one 400 kV D/C Quad Moose ACSR lines from Naubise.

iii. 400 kV GIS bay, 1 nos. bay for connecting (3+1), 1-Ph, 400/√3/220/√3/33 KV, 167 MVA, 1-Ph Interconnecting Autotransformers, along with supply and installation of 4 Nos. (3+1 spare) single phase 400/√3/220/√3/33 KV, 167 MVA Auto Transformer.

iv. 400 kV GIS bay, 1 nos. bays for connecting 420 kV, 50 MVAR Shunt Reactor along with supply and installation of reactor.

v. Under construction, 1 nos. of 220 kV line bay (AIS) shall be used for 220 kV side ICT bay with necessary augmentation.

vi. 630 KVA, LT Transformer along with 33 kV Bays, 1 Nos. for 33/0.4 KV, 630 KVA, LT Transformer.

2.1.2 Inaruwa Substation

The specification includes design, engineering, manufacture, fabrication, testing at manufacturers works, supply & delivery, unloading at site, storage, erection, testing and commissioning at site of the complete 400 kV switchyard including indoor SF6 gas insulated metal enclosed switchgear (GIS), 400 kV GIS ducts for making connections with outdoor transformers, bus shunt reactors and 400 kV overhead lines, 400 kV outdoor equipment, extension of 220 kV under construction switchyard (AIS type), 220 kV outdoor equipment, Control & protection, Substation Automation System, communication System and other electrical and mechanical auxiliary systems, associated civil works, internal roads, drains, necessary buildings etc. as described below:

2.1.2.1 Construction of a new 400 kV (GIS)/220 kV (AIS-extension) substation at Inaruwa with the provision of following bays as per Single Line Diagram. (The SF6 Gas Insulated Switchgear (GIS) of one-and- a half Breaker Bus Scheme shall be 420 kV, 5000A, 50 kA short circuit rating for 1 sec. and involves installation of following number of Bays):

i. 400 kV GIS bays, 2 nos. to terminate one 400 kV D/C Quad Moose ACSR lines from Dhalkebar.

ii. 400 kV GIS Bays, 3 nos. for connecting 3-Φ, 315 MVA, 400/220/33 kV Interconnecting Auto Transformer along with supply and installation of autotransformers.

iii. 400 kV Bays, 1 nos. for connecting 420 kV, 50 MVAR Bus Shunt Reactor along with supply and installation of reactor.

iv. 220 kV bays, 3 Nos. for 400/220/33 KV, 315 MVA, 3-Ph Auto transformers

v. 630 KVA, LT Transformer along with 33 kV Bays, 1 Nos. for 33/0.4 KV, 630 KVA, LT Transformer.

3.0 The detailed scope of work is brought out in subsequent clauses of this chapter.

3.1 400kV Hetauda GIS Substation

3.1.1 Design, engineering, manufacture, testing, supply including transportation & insurance, storage, erection, testing and commissioning of following equipments and items at 400(GIS)/220(AIS) kV Hetauda GIS substation complete in all respect:

1) 400 kV System

The 420 kV SF6 gas insulated switchgear shall have one and a half breaker bus bar arrangement. The Switchgear shall be complete with all necessary terminal boxes, SF6 gas filling, interconnecting power and control wiring, grounding connections, gas monitoring equipment & piping and support structures along with base plate & foundation bolts for fixing the switchgear with raft foundations complete in all respect and consisting of the following major items.

1.1 420kV, 50KA for 1 sec., Two (2) sets of 3 single-phase (isolated), SF6 gas insulated, metal-enclosed 5000A bus bars, each enclosed in three individual bus-enclosures running along the length of the switchgear to interconnect each of the circuit breaker bay module. Each bus bar set shall comprise of:

i. Three Nos. 5000A, individual bus bars enclosures running across the length of the switch gear to inter-connect each of the circuit breaker bay modules in one and half breaker bus system.

ii. Three Nos. inductive potential transformers, complete with isolating switch.

iii. One No. 3-phase, group operated safety-grounding switch, complete with manual and motor driven operating mechanisms.

iv. One Bay Module Control Cabinet/Local Control Cubicle for Bus Bar System.

v. Interface module (under present scope) with the Isolating link for future extension of Bus bar module (on one side).

vi. One lot of SF6 gas monitoring system, barriers, pressure switches etc. for the complete bay module, terminal boxes, interconnecting wires, grounding, support structures, platform etc. as required.

1.2 420kV, 50KA for 1 sec., SF6 gas insulated metal enclosed **Line feeder bay module**, each set comprising of:-

i. One set of three single-phase (isolated), 4000A, SF6 insulated circuit breaker complete with separate operating mechanism for each pole.

ii. Three Nos. 1-phase, 4000A, 6-core, multi ratio, current transformers duly distributed on both side of circuit breaker as per single line diagram.

iii. Three Sets of three-pole, 4000A, group-operated disconnectors with safety grounding switch, each complete with manual and motor driven operating mechanism.

iv. One Set of three-pole group operated high speed grounding switch complete with manual and motor driven operating mechanism.

v. Three single-phase SF6 gas insulated terminal connections for inter-connection between GIS Bus and outdoor equipment including SF6 to Air Bushing.

vi. Three Nos. 1-phase, 4000A, SF6 ducts inside the GIS hall (up to the outer edge of the wall of GIS Hall).

vii. One Bay Module Control Cabinet including Bay Controller (Local Control Cubicle)

viii. One lot of SF6 gas monitoring system, barriers, pressure switches etc. for the complete bay module, terminal boxes, interconnecting wires, grounding, support structures, platform etc. as required.

1.3 400kV, 50kA for 1 sec, SF6 gas insulated metal enclosed **Auto Transformer bay module**, each set comprising of :-

i. One set of three single-phase (isolated), 2000A, SF6 gas insulated circuit breaker with control switching device, complete with operating mechanism.

ii. Three Nos. 1-phase, 4000A, 6-core, multi ratio, current transformers duly distributed on both side of circuit breaker as per single line diagram.

iii. Three Sets of three pole, 2000A group operated disconnector with safety grounding switch complete with manual and motor driven operating mechanism.

iv. One No., three pole groups operated high-speed grounding switch complete with manual and motor driven operating mechanism.

v. Three single-phase SF6 gas insulated terminal connections for inter-connection between GIS Bus and outdoor equipment including SF6 to Air Bushing.

vi. Three Nos. 2000A single-phase SF6 ducts inside the GIS hall (up to the outer edge of the wall of GIS Hall).

vii. Three nos.1-phase, 2000A, 50 kA, individual pole operated, isolator switches, complete with manual and motor driven operating mechanisms for switching of Spare ICT through 420kV Auxiliary bus . The isolator must meet the operational requirement in terms of insulation withstand requirement for connecting the same to auxiliary bus.

viii. One Bay Module Control Cabinet including Bay Controller.

ix. One lot of SF6 gas monitoring system, barriers, pressure switches etc. for the complete bay module, terminal boxes, interconnecting wires, grounding, support structures, platform etc. as required.

1.4 400kV, 50kA for 1 second, SF6 gas insulated metal enclosed **Bus shunt reactor module** each set comprising of :-

i. One set of three single-phase (isolated), 4000A, SF6 gas insulated circuit breaker with control switching device, complete with operating mechanism.

ii. Three Nos. 1-phase, 4000A, 6-core, multi ratio, current transformers duly distributed on both side of circuit breaker as per single line diagram.

iii. Three Sets of three pole, 4000A group operated disconnector with safety grounding switch complete with manual and motor driven operating mechanism.

iv. One No., three pole groups operated high-speed grounding switch complete with manual and motor driven operating mechanism.

v. Three single-phase SF6 gas insulated terminal connections for inter-connection between GIS Bus and outdoor equipment including SF6 to Air Bushing.

vi. Three Nos. 4000A single-phase SF6 ducts inside the GIS hall (up to the outer edge of the wall of GIS Hall).

vii. One Bay Module Control Cabinet including Bay Controller.

viii. One lot of SF6 gas monitoring system, barriers, pressure switches etc. for the complete bay module, terminal boxes, interconnecting wires, grounding, support structures, platform etc. as required.

1.5 420kV, 50kA for 1 second, SF6 gas insulated metal enclosed **Tie bay module** (For Lines bays and Shunt Reactors Bays) comprising of:-

i. One set of three single-phase (isolated), 4000A, SF6 insulated circuit breaker complete with operating mechanism.

ii. Three Nos. 1-phase, 4000A, 6-core, multi ratio, current transformers duly distributed on both side of circuit breaker as per single line diagram.

iii. Two Nos. 3-phase, 4000A, group operated isolator switches, complete with manual and motor driven operating mechanisms.

iv. Two Nos. 3-phase, group operated safety-grounding switches, complete with manual and motor driven operating mechanisms.

v. One Bay Module Control Cabinet including Bay Controller.

vi. One lot of SF6 gas monitoring system, barriers, pressure switches etc. for the complete bay module, terminal boxes, interconnecting wires, grounding, support structures, platform etc. as required.

1.6 420kV, 50kA for 1 second, SF6 gas insulated metal enclosed **Tie bay module** (For Auto Transformers Bays) comprising of:-

i. One set of three single-phase (isolated), 2000A, SF6 insulated circuit breaker complete with operating mechanism.

ii. Three Nos. 1-phase, 4000A, 6-core, multi ratio, current transformers duly distributed on both side of circuit breaker as per single line diagram.

iii. Two Nos. 3-phase, 2000A, group operated isolator switches, complete with manual and motor driven operating mechanisms.

iv. Two Nos. 3-phase, group operated safety-grounding switches, complete with manual and motor driven operating mechanisms.

v. One Bay Module Control Cabinet including Bay Controller.

vi. One lot of SF6 gas monitoring system, barriers, pressure switches etc. for the complete bay module, terminal boxes, interconnecting wires, grounding, support structures, platform etc. as required.

1.7 420 kV Auxiliary Bus to connect spare unit of Transformer

i. One number 1-phase (isolated) SF6 ducts inside GIS hall (up to outer edge of wall) for connection of spare unit with one ICT bay.

ii. One nos. 1-phases, 2000A, 50kA individual operated safety grounding switches complete with manual and motor driven operating mechanisms.

iii. End Piece module with the test link for Future extension of Auxiliary Bus module at end. The end piece module may 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.

iv. Local Bay control cubicle

v. One lot of SF6 gas monitoring system, barriers, pressure switches etc. for

the complete bay module, terminal boxes, interconnecting wires, grounding, support structures, platform etc. as required.

2) Pre-insert resistor (PIR) is required for all Main & Tie circuit breakers for line bays and Control switching device (CSD) is required for Main & Tie circuit breakers of Auto Transformers, Bus reactor bays as per specification. However, pre-insert resistor (PIR) which are required for all Main & Tie circuit breakers for line bays may be replaced with alternate suitable device (like control switching device (CSD), capacitance Current Switching device) provided that contractor shall ensure the proposed device shall also limit the switching surges as per technical specification with justification in line with relevant international standards (IEC/IEEE) and provide the details of the same along with bid. The price for the same is deem to be included in the GIS Module.

3) Testing & Maintenance Equipment will be required of 420kV GIS as per specification.

4) SF6 gas ducts (including support structures, gas monitoring devices, gas barrier pressure switch) from outside (i.e. wall surface) of the GIS building to center line of SF6/Air Bushing or SF6/Oil Bushings shall be as per bid price schedule. SF6 gas Ducts inside GIS hall are part of GIS Module.

5) SF6/Air Bushing or SF6/Oil Bushings along with terminal connectors & support structure for outdoor connections to connect GIS with Transformers, Bus Reactors and overhead line are part of GIS Module.

6) During Engineering contractor is required to furnish the detailed document enlisting, each and every GIS Module (indoor and outdoor) complete along with its enclosure, gasket and all active parts such as conductor, conductor joints, corona shield etc. identifiable. The Purpose of above said document is to identify (as a part no.) each and every GIS Module individually in supplied GIS installation.

7) The incoming 400 kV quad moose double circuit lines Bays from Dhalkebar is supposed to be charged at 200 kV Voltage level at under construction 220/132 kV Hetauda Substation. Under present scope of the contract, same 400 kV lines shall be terminated in 400 kV bays and the under construction one nos. of 220 kV line bay shall be used as 220 kV ICT bays. The 220 kV Bus Bar Scheme is Double Main and Transfer Bus. The necessary augmentation, connection and reinforcement to use the existing 220 kV Lines bays as ICT bays shall be under the scope of Contractor.

8) Supply, Erection, testing & commissioning of 4 nos. 400/√3/220/√3/33 KV, 167 MVA, 1-Ph Autotransformers (Total Bank size 500 MVA). The scope also includes supply of transformer bushing end terminal connectors suitable for 400kV overhead connection which shall be connected with 400 kV GIS ICT Bay and twin Moose ACSR Conductor bushing end terminal connectors suitable for 220 kV twin Moose ACSR Conductor, complete in all respect for the above mentioned

auto transformers as per technical specification. Transformer Bushing for voltage of 52 kV and above shall be Resin Impregnated Paper RIP bushing with composite polymer insulator shall be manufactured and tested as per latest IEC Standards.

Connection arrangement of spare unit of transformer with other units shall be made by isolator switching as described in Chapter-5.

All associated equipments like 420 kV GIS Auxiliary Bus to connect spare unit of Transformer as described above and 220 kV AIS Auxiliary Bus along with all associated materials like isolators, Bus post insulators, Aluminium tube, conductors, clamps & connectors, insulator strings, hardware, cables, support structures, required for the above-mentioned arrangement are deem to be included in the present scope of the work.

9) Supply, Erection, testing & commissioning of 1 nos. 420kV, 3 Ph. 50 MVAR Bus Shunt Reactors, complete in all respect for the above-mentioned Bus Reactor. The scope also includes supply of bus shunt reactor bushing end terminal for 400kV overhead connection which shall be connected with 400 kV GIS Bay complete in all respect for the above shunt reactors as per technical specification. Reactors Bushing for voltage of 52 kV and above shall be Resin Impregnated Paper RIP bushing with composite polymer insulator shall be manufactured and tested as per latest IEC Standards.

10) 400kV CVTs and Surge Arrestors (AIS type) and 220kV & 33 kV Surge Arrestors (AIS type).

11) Outer insulator housing for 400kV CVTs and Surge Arrestors, 220 kV current transformers and surge arresters, 400 kV, 220kV Bus Post Insulators shall be polymer conforming to requirements technical Specifications.

12) One nos. 630 kVA, 33/0.4 kV LT Transformer along with 72.5kV circuit breakers, isolators, earth switches, current transformers, capacitor voltage transformers, PT and surge arresters for tertiary loading as per BPS. These LT transformers should not be used for construction purposes.

13) 250 KVA Silent type outdoor DG Set with acoustic enclosure.

14) 400 kV, 220kV, 72.5 and 33 kV Bus Post Insulators, Composite Long rod polymer insulator strings and hardware, clamps & connectors, Equipment terminal connectors (including terminal connectors for Transformer and Reactors), Conductors, Aluminum tubes, Bus bar and earthing materials, Bay marshalling box, spacers, cable supporting angles/channels, Cable trays & covers, Junction box, buried cable trenches etc. as required. Due to space constraint, tertiary auxiliary bus & delta formation of autotransformer is not possible by overhead Al-tube arrangement, same shall be done by using 52 kV XLPE cable and deem to be included in the present scope of contract.

15) Sub-station automation system based on IEC 61850 including hardware and software for remote control station along with associated equipments for following bays (bay as defined in Technical Specification, Chapter - Substation Automation):

- 400kV : 4 Line Bays, 1 ICT Bays, 1 Reactor Bays, 4 Tie Bays
- 220 kV : 1 Bays (ICT Bays)
- 33 kV: 1 Bays (Station Transformers Bays)
- Auxiliary System: 1 Set

The contractor shall also supply necessary BCU for monitoring and control of auxiliary supply including operation of Isolator associated with auxiliary transformer.

The remote operation of the 400/220 kV Dhalkebar & Inaruwa substation is proposed to be done from Hetauda substation and the mode of communication shall be Optical Fibre link.

Further, the under construction 220 kV Hetauda (AIS) substation shall be equipped with substation Automation system (SCADA System) based on IEC 61850. Operator Workstations (HMI) and all necessary accessories and software are included in the present scope of the work, bidder shall also require to supply all necessary hardware and software to integrate SAS with the under construction Substation Automation System including up-dation of system database, displays, and development of additional displays and reports as per requirement. For under construction 220 kV low impedance Bus bar protection shall be used. Bidders are requested to visit the substation site and make own acquaint with the scope of works as described herein. The make of existing SAS shall be provided during detailed Engineering.

16) For 400kV Dhalkebar–Hetauda D/C Lines (planned to be charged at 220 kV Voltage level initially). Siemens Make 2 Nos. of Digital Protection Coupler is already installed at Dhalkebar End. Digital protection Coupler matching with Dhalkebar end (suitable for interfacing with E1 port of SDH equipment) and associated power & control Cables, Fibre cables and Accessories for Hetauda end of Dhalkebar-Hetauda 400 kV Lines and Hetauda end of Naubise-Hetauda 400 kV Lines are under the present scope of contract and shall be used for Tele protection application. Each DPC were interface with SDH/MUX telecommunication terminal equipment located in the Control Room required for the communication for the each 400 kV Lines with present SAS and SCADA system of the LDC. However, the DPC, for Teleprotection, Voice & data for Naubise end of 400kV Naubise-Hetauda D/C Line is being provided in separate Contract.

The broad Scope of FO based Communication Equipment and PMU shall include planning, designing, engineering, supply, transportation, insurance, delivery at site, unloading handling, storage, installation, termination, testing, training and demonstration for acceptance, commissioning and documentation for :

i. SDH/termination Equipment along with suitable interfaces and line cards.

ii. PMU Equipment along with interfaces.

iii. All cabling, wiring, Digital Distribution frame patch facilities and interconnection to the supplied equipment at the defined interfaces,

iv. System integration of all supplied subsystem

v. Integration with the existing communication system based on SDH and PDH of employer

vi. Integration of supplied subsystem with SCADA system, communication equipment, PABX of RLDC/LDC(for voice)

vii. Network Manager System (both software and hardware) including VOIP telephone instrument with one common switch (min. 4 port) including hardware and software.

The Fibre optic Terminal Equipment based on SDH technology and PMU unit with Optical Line Termination Equipment, Digital Multiplexer, hardware accessories etc. along with approach optical fibre (as per requirement from JB to ODF box), necessary interfacing and its integration work (at Hetauda & LDC Kathmandu) for onward transmission of Data and Voice communication up to LDC Kathmandu is included in the contract. The details communication scheme of the same shall be attached in the drawings given with this specification.

17) **SCADA Integration**

All the online monitoring equipment i.e. Optical Temperature Sensors & Measuring Unit, Online Dissolved Gas (Multi-gas) and Moisture Analyzer, On-line insulating oil drying system (Cartridge type) provided for individual transformer/reactor unit including spare (if any), are IEC 61850 compliant (either directly or through a Gateway). These monitoring equipment are required to be integrated with SAS through managed Ethernet switch conforming to IEC 61850. This Ethernet switch shall be provided in MB by the contractor. The switch shall be powered by redundant DC supply (220V DC). Ethernet switch shall be suitable for operation at ambient temperature of 50 Deg C. All required power & control cables including optical cable, patch chord (if any) up to MB shall be in the scope of contractor. All cable from Digital RTCC to MB shall also be in the scope of contractor. Further, any special cable between MB to switchyard panel room/control room shall be in the scope of contractor. However, fiber optic cable, power cable, control cables, as applicable, between MB to switchyard panel room/control room and power supply (AC & DC) to MB and integration of above said IEC-61850 compliant equipment with Substation Automation System shall be under the scope of sub-station contractor.

Augmentation and integration work related to SCADA System

The 400/220kV bays under present scope at Hetauda substation shall be integrated by the contractor into existing SCADA system of Siemens 'SINAUT Spectrum"(version 4.3.2) installed at Master Station i.e. Nepal Electricity Authority Load Dispatch Centre (located in Siuchatar, Kathmandu). The integration shall include all hardware and software required at the Control Centre as well as necessary data base, display generation and upgrades for proposed control and monitoring of station and Network Analysis. The above activities shall be carried out as appropriate, in all of the 4 stations viz. New Dhalkebar, New Inaruwa, New Hetauda and the Load Dispatch Centre. The manufacturers of the existing SCADA system is Siemens Germany. The existing communication protocol used for SCADA at LDC Kathmandu is IEC 101. In the present scope of work, the data for SCADA purpose shall be obtained from the Substation Automation System (based on IEC 61850) using Gateway port with communication protocol IEC 101/104 or as per requirement being provided at Hetauda.

18) Complete relay and protection system for 400kV bays (Line bays, reactor bays and ICT Bays), 220 kV ICT bays, 33 kV Station Transformer bay are under present scope as per Chapter –Control and Relay panels.

19) Fire protection system (HVW spray & hydrant system) for 4 nos. of 400/√3/220/√3/33 KV, 167 MVA, 1-Ph Autotransformers (Total Bank size 500 MVA) and 1nos. 420kV, 50MVAR Reactors including extension of main water header (available at under construction Fire Fighting Pump House).The HVWS system shall be tapped from the Existing fire water system. The tapping point location & Existing firefighting system piping layout shall be provide to the successful bidders during detail engineering. FFPH & water Tank are not envisaged in the present scope of Contract.

20) 1.1kV grade Power & Control Cable along with complete accessories to complete the scope of works.

21) The earth mat for GIS earthing and the yard earthing required as per specification is in the bidder scope. The earth mat already exist in the 220 kV switchyard area. All the AIS/GIS equipments, Transformer, Reactors shall be earthed and this earth mat shall be connected to the Existing 220 kV earth mat by the contractor. Any additional earthing materials required shall be in the present scope of work.

22) Lattice and pipe structures (galvanized): Standard lattice gantry structures (400/220/75.5/33kV Beams Towers and Lightening Mast), pipe/lattice support structure for equipment (pipe structures shall be used for 220 & 400 kV equipment support) and Structures for PEB Building and AHU room etc. shall be prepared by the contractor and put up for approval of NEA during detailed engineering.

23) Complete lighting and illumination of switchyard under present scope of work.

24) Visual monitoring system for watch and ward of Substation premises as per Annexure-V.

25) EOT Crane as per Technical Specification is proposed in the GIS Building for handling and subsequent maintenance of GIS equipment. The bidder is required to keep the weight & size of the packages accordingly. Slings of required capacity for handling of GIS equipment/components shall be provided by the supplier. Embedment/Block outs, if any to be provided shall be considered and provided by the bidder. The bidder shall furnish his views regarding the proposed capacity of the crane.

26) LT switchgear (AC/DC Distribution boards).

As presently, only one LT transformer is envisaged as an incomer-1 of the Main Switch Board, the Incomer-2 of Main switch Board under present scope shall be fed from existing 400V ACDB board located in existing Control Room Building. Double run of 3.5Core x300Sq mm Aluminium Power Cable of approximate length 200 mtrs shall be laid and terminated for above purpose. One number Adapter Panel for extension of existing LT AC (400V) system (located inside existing Substation Control Room) with 1 No. 600A MCCB for feeding Main switch board (placed inside new Control Room Building) is in present scope of work. Automatic changeover between Incomer-1, Incomer-2 and DG set is to be carried out during the failure of supply in one/or both the incomers are included as per specification in the present scope of contract. The existing AC/DC drawings shall be provided during detail engineering.

27) Batteries & Battery Chargers

The capacity of Battery & Battery charger shall be worked out by the bidder for complete 400kV substation scope including future bays as shown in the Single line diagram. For Battery sizing calculations, DC drives shall be considered for future 400kV GIS modules. However minimum battery size for 220 V battery shall be 600 AH and for 48 V battery shall be 600 AH. The necessary DCDB is also in the present scope of work.

In addition, 600 AH, 220 V battery and battery charger with its distribution to be installed at Dhalkebar Substation are included in the present scope of contract as indicated in the price schedules.

28) Any other equipment/material required for completing the specified scope.

29) Design, engineering, manufacture, testing, and supply on FOR destination basis Including transportation & insurance, storage at site.

30) Civil works - The scope of work shall include but shall not be limited to the Following–

Design, Engineering and civil work (as per Contractor supplied drawings) for:

a) PEB GIS Building for 400kV: The size of 400kV GIS Building shall be suitable to accommodate 6 complete diameter (4 present plus 2 future as per availability of space) bays in addition to the maintenance bay. The AHU room shall be provided for as a part of GIS Buildings. Necessary provision for future expansion shall be made in GIS Hall.

b) Control Room Building, DG Enclosure complete as per technical specifications.

c) Foundation for GIS Hall Building, AHU Room, Control Room Building, DG Enclosure.

d) Foundation for GIS bus duct supporting structures inside and outside the GIS hall.

e) Foundation for 4 nos. of 400/√3/220/√3/33 KV, 167 MVA, 1-Ph Autotransformers (Total Bank size 500 MVA) and 1nos. 420kV, 50MVAR Reactors along with jacking pad, rail tracks, pylon supports etc. to complete the scope of works.

f) Fire resistant wall between Transformer/Reactors as per enclosed GA drawing.

g) Foundation for GIS equipment, GIS (SF6) to Air bushing, GIS (SF6) to Oil bushing, & supporting structure.

h) Cable trenches inside GIS hall, control room building and DG room.

i) Cable trenches along with covers, road/rail crossings, sump pits and cable trench crossings with roads or drains etc.

j) All roads as shown in GA drawing including culverts. The roads shall be of RCC type.

k) Antiweed treatment, PCC and Stone spreading in switchyard area under present scope.

l) Drains along with drain crossings with cable trenches. Drain layout shall be developed by the contractor. Fencing for switchyard and switchyard gates. Dismantling/re-erection of existing fence as per requirement is also included.

m)Diversion of existing Canal/Nala/Drains as per attached General arrangement drawings as well as dismantling of existing Canal/Nala/Drains and hume pipe located at 400 kV Switchyard is also included.

a) Layout and details of Water supply (including bore well) and Sewage system complete as per technical specification.

n) Soil investigation, contouring, leveling and filling. The leveling and filling (to an approximate depth of 1.0 to 2.5 mtrs) in the area under present scope of work inside substation is to be carried out to achieve finished ground level. The finished ground level shall be provided during detail engineering.

o) Foundation for lighting poles, Bay marshalling box, panels and control cubicles of equipments wherever required shall be as per design and drawings of contractor vendor drawings.

3.2 400kV Inaruwa GIS Substation

3.2.1 Design, engineering, manufacture, testing, supply including transportation & insurance, storage, erection, testing and commissioning of following equipments and items at 400(GIS)/220(AIS) kV Inaruwa GIS substation complete in all respect:

1) 400 kV System

The 400 kV SF6 gas insulated switchgear shall have one and a half breaker bus bar arrangement. The Switchgear shall be complete with all necessary terminal boxes, SF6 gas filling, interconnecting power and control wiring, grounding connections, gas monitoring equipment & piping and support structures along with base plate & foundation bolts for fixing the switchgear with raft foundations complete in all respect and consisting of the following major items.

1.1 420kV, 50KA for 1 sec., Two (2) sets of 3 single-phase (isolated), SF6 gas insulated, metal-enclosed 5000A bus bars, each enclosed in three individual bus-enclosures running along the length of the switchgear to interconnect each of the circuit breaker bay module. Each bus bar set shall comprise of:

i. Three Nos. 5000A, individual bus bars enclosures running across the length of the switch gear to inter-connect each of the circuit breaker bay modules in one and half breaker bus system.

ii. Three Nos. inductive potential transformers, complete with isolating switch.

iii. One No. 3-phase, group operated safety-grounding switch, complete with manual and motor driven operating mechanisms.

iv. One Bay Module Control Cabinet/Local Control Cubicle for Bus Bar System.

v. Interface module (under present scope) with the Isolating link for future extension of Bus bar module (on one side).

vi. One lot of SF6 gas monitoring system, barriers, pressure switches etc. for

the complete bay module, terminal boxes, interconnecting wires, grounding, support structures, platform etc. as required.

1.2 420kV, 50KA for 1 sec., SF6 gas insulated metal enclosed **Line feeder bay module**, each set comprising of:-

i. One set of three single-phase (isolated), 4000A, SF6 insulated circuit breaker complete with separate operating mechanism for each pole.
ii. Three Nos. 1-phase, 4000A, 6-core, multi ratio, current transformers duly distributed on both side of circuit breaker as per single line diagram.
iii. Three Sets of three-pole, 4000A, group-operated disconnectors with safety grounding switch, each complete with manual and motor driven operating mechanism.
iv. One Set of three-pole group operated high speed grounding switch complete with manual and motor driven operating mechanism.
v. Three single-phase SF6 gas insulated terminal connections for inter-connection between GIS Bus and outdoor equipment including SF6 to Air Bushing.
vi. Three Nos. 1-phase, 4000A, SF6 ducts inside the GIS hall (up to the outer edge of the wall of GIS Hall).
vii. One Bay Module Control Cabinet including Bay Controller (Local Control Cubicle)
viii. One lot of SF6 gas monitoring system, barriers, pressure switches etc. for the complete bay module, terminal boxes, interconnecting wires, grounding, support structures, platform etc. as required.

1.3 400kV, 50kA for 1 sec, SF6 gas insulated metal enclosed **Auto Transformer bay module**, each set comprising of :-

i. One set of three single-phase (isolated), 2000A, SF6 gas insulated circuit breaker with control switching device, complete with operating mechanism.
ii. Three Nos. 1-phase, 4000A, 6-core, multi ratio, current transformers duly distributed on both side of circuit breaker as per single line diagram.
iii. Three Sets of three pole, 2000A group operated disconnector with safety grounding switch complete with manual and motor driven operating mechanism.
iv. One No., three pole groups operated high-speed grounding switch complete with manual and motor driven operating mechanism.
v. Three single-phase SF6 gas insulated terminal connections for inter-connection between GIS Bus and outdoor equipment including SF6 to Air Bushing.
vi. Three Nos. 2000A single-phase SF6 ducts inside the GIS hall (up to the outer edge of the wall of GIS Hall).

vii. One Bay Module Control Cabinet including Bay Controller.

viii. One lot of SF6 gas monitoring system, barriers, pressure switches etc. for the complete bay module, terminal boxes, interconnecting wires, grounding, support structures, platform etc. as required.

1.4 400kV, 50kA for 1 second, SF6 gas insulated metal enclosed **Bus shunt reactor module** each set comprising of :-

i. One set of three single-phase (isolated), 4000A, SF6 gas insulated circuit breaker with control switching device, complete with operating mechanism.

ii. Three Nos. 1-phase, 4000A, 6-core, multi ratio, current transformers duly distributed on both side of circuit breaker as per single line diagram.

iii. Three Sets of three pole, 4000A group operated disconnector with safety grounding switch complete with manual and motor driven operating mechanism.

iv. One No., three pole groups operated high-speed grounding switch complete with manual and motor driven operating mechanism.

v. Three single-phase SF6 gas insulated terminal connections for inter-connection between GIS Bus and outdoor equipment including SF6 to Air Bushing.

vi. Three Nos. 4000A single-phase SF6 ducts inside the GIS hall (up to the outer edge of the wall of GIS Hall).

vii. One Bay Module Control Cabinet including Bay Controller.

viii. One lot of SF6 gas monitoring system, barriers, pressure switches etc. for the complete bay module, terminal boxes, interconnecting wires, grounding, support structures, platform etc. as required.

1.5 420kV, 50kA for 1 second, SF6 gas insulated metal enclosed **Tie bay module** (For Lines bays and Shunt Reactors Bays) comprising of:-

i. One set of three single-phase (isolated), 4000A, SF6 insulated circuit breaker complete with operating mechanism.

ii. Three Nos. 1-phase, 4000A, 6-core, multi ratio, current transformers duly distributed on both side of circuit breaker as per single line diagram.

iii. Two Nos. 3-phase, 4000A, group operated isolator switches, complete with manual and motor driven operating mechanisms.

iv. Two Nos. 3-phase, group operated safety-grounding switches, complete with manual and motor driven operating mechanisms.

v. One Bay Module Control Cabinet including Bay Controller.

vi. One lot of SF6 gas monitoring system, barriers, pressure switches etc. for

the complete bay module, terminal boxes, interconnecting wires, grounding, support structures, platform etc. as required.

1.6 420kV, 50kA for 1 second, SF6 gas insulated metal enclosed **Tie bay module** (For Auto Transformers Bays) comprising of:-

i. One set of three single-phase (isolated), 2000A, SF6 insulated circuit breaker complete with operating mechanism.

ii. Three Nos. 1-phase, 4000A, 6-core, multi ratio, current transformers duly distributed on both side of circuit breaker as per single line diagram.

iii. Two Nos. 3-phase, 2000A, group operated isolator switches, complete with manual and motor driven operating mechanisms.

iv. Two Nos. 3-phase, group operated safety-grounding switches, complete with manual and motor driven operating mechanisms.

v. One Bay Module Control Cabinet including Bay Controller.

vi. One lot of SF6 gas monitoring system, barriers, pressure switches etc. for the complete bay module, terminal boxes, interconnecting wires, grounding, support structures, platform etc. as required.

2) Pre-insert resistor (PIR) is required for all Main & Tie circuit breakers for line bays and Control switching device (CSD) is required for Main & Tie circuit breakers of Auto Transformers, Bus reactor bays as per specification. However, pre-insert resistor (PIR) which are required for all Main & Tie circuit breakers for line bays may be replaced with alternate suitable device (like control switching device (CSD), capacitance Current Switching device) provided that contractor shall ensure the proposed device shall also limit the switching surges as per technical specification with justification in line with relevant international standards (IEC/IEEE) and provide the details of the same along with bid. The price for the same is deem to be included in the GIS Module.

3) Testing & Maintenance Equipment will be required of 420kV GIS as per specification.

4) SF6 gas ducts (including support structures, gas monitoring devices, gas barrier pressure switch) from outside (i.e. wall surface) of the GIS building to center line of SF6/Air Bushing or SF6/Oil Bushings shall be as per bid price schedule. SF6 gas Ducts inside GIS hall are part of GIS Module.

5) SF6/Air Bushing or SF6/Oil Bushings along with terminal connectors & support structure for outdoor connections to connect GIS with Transformers, Bus Reactors and overhead line are part of GIS Module.

6) During Engineering contractor is required to furnish the detailed document enlisting, each and every GIS Module (indoor and outdoor) complete along with its enclosure, gasket and all active parts such as conductor, conductor joints, corona shield etc. identifiable. The Purpose of above said document is to identify

(as a part no.) each and every GIS Module individually in supplied GIS installation.

7) The under construction 220 kV substation Bus Bar Scheme is Double Main and Transfer Bus. The necessary extension, augmentation, connection and reinforcement of under construction 220 kV substation for making three(3) ICT bays with provision for future bay shall be under the scope of Contractor.

8) Supply, Erection, testing & commissioning of there(3) nos. 400/220/33 KV, 315 MVA, 3-Ph Autotransformers. The scope also includes supply of transformer bushing end terminal connectors suitable for 400kV overhead connection which shall be connected with 400 kV GIS ICT Bay and twin Moose ACSR Conductor bushing end terminal connectors suitable for 220 kV twin Moose ACSR Conductor, complete in all respect for the above mentioned auto transformers as per technical specification. Transformer Bushing for voltage of 52 kV and above shall be Resin Impregnated Paper RIP bushing with composite polymer insulator shall be manufactured and tested as per latest IEC Standards.

9) Supply, Erection, testing & commissioning of 1 nos. 420kV, 3 Ph. 50 MVAR Bus Shunt Reactors, complete in all respect for the above-mentioned Bus Reactor. The scope also includes supply of bus shunt reactor bushing end terminal for 400kV overhead connection which shall be connected with 400 kV GIS Bay complete in all respect for the above shunt reactors as per technical specification. Reactors Bushing for voltage of 52 kV and above shall be Resin Impregnated Paper RIP bushing with composite polymer insulator shall be manufactured and tested as per latest IEC Standards.

10) 400kV CVTs and Surge Arrestors (AIS type).

11) 220kV circuit breakers, isolators, earth switches, current transformers and surge arresters (AIS type).

12) Outer insulator housing for 400kV CVTs and Surge Arrestors, 220 kV current transformers and surge arresters, 400 kV, 220kV Bus Post Insulators shall be polymer conforming to requirements technical Specifications.

13) One nos. 630 kVA, 33/0.4 kV LT Transformer along with 72.5kV circuit breakers, isolators, earth switches, current transformers, capacitor voltage transformers, PT and surge arresters for tertiary loading as per BPS. These LT transformers should not be used for construction purposes.

14) 250 KVA Silent type outdoor DG Set with acoustic enclosure.

15) 400 kV, 220kV, 72.5 and 33 kV Bus Post Insulators, Composite Long rod polymer insulator strings and hardware, clamps & connectors, Equipment terminal connectors (including terminal connectors for Transformer and Reactors), Conductors, Aluminum tubes, Bus bar and earthing materials, Bay marshalling box, spacers, cable supporting angles/channels, Cable trays & covers, Junction box, buried cable trenches etc. as required.

16) Sub-station automation system based on IEC 61850 including hardware and software for remote control station along with associated equipments for following bays (bay as defined in Technical Specification, Chapter - Substation Automation):

- 400kV : 2 Line Bays, 3 ICT Bays, 1 Reactor Bays, 3 Tie Bays
- 220 kV : 3 Bays (ICT Bays)
- 33 kV : 1 Bays (Station Transformer Bay)
- Auxiliary System: 1 Set

The contractor shall also supply necessary BCU for monitoring and control of auxiliary supply including operation of Isolator associated with auxiliary transformer.

The remote operation of the 400/220 kV Dhalkebar & Inaruwa substation is proposed to be done from Hetauda substation and the mode of communication shall be Optical Fibre link.

Further, the under construction 220 kV Inaruwa (AIS) substation shall be equipped with substation Automation system (SCADA System) based on IEC 61850. Operator Workstations (HMI) and all necessary accessories and software are included in the present scope of the work, bidder shall also require to supply all necessary hardware and software to integrate SAS with the under construction Substation Automation System including up-dation of system database, displays, and development of additional displays and reports as per requirement. For under construction 220 kV low impedance Bus bar protection shall be used. Bidders are requested to visit the substation site and make own acquaint with the scope of works as described herein. The make of existing SAS shall be provided during detailed Engineering.

17) For 400kV Dhalkebar–Hetauda D/C Lines, Siemens Make 2 Nos. of Digital Protection Coupler is already installed at Dhalkebar End. Matching Digital protection Coupler (suitable for interfacing with E1 port of SDH equipment) and associated power & control Cables, Fibre cables and Accessories for Inaruwa end of Dhalkebar lines are under the present scope of contract and shall be used for Tele protection application. Each DPC were interface with SDH/MUX telecommunication terminal equipment located in the Control Room required for the communication for the each 400 kV Lines with present SAS and SCADA system of the LDC.

The broad Scope of FO based Communication Equipment and PMU shall include planning, designing, engineering, supply, transportation, insurance, delivery at site, unloading handling, storage, installation, termination, testing, training and demonstration for acceptance, commissioning and documentation for :

i. SDH/termination Equipment along with suitable interfaces and line cards.

ii. PMU Equipment along with interfaces.

iii. All cabling, wiring, Digital Distribution frame patch facilities and interconnection to the supplied equipment at the defined interfaces,

iv. System integration of all supplied subsystem

v. Integration with the existing communication system based on SDH and PDH of employer

vi. Integration of supplied subsystem with SCADA system, communication equipment, PABX of RLDC/LDC(for voice)

vii. Network Manager System (both software and hardware) including VOIP telephone instrument with one common switch (min. 4 port) including hardware and software.

The Fibre optic Terminal Equipment based on SDH technology and PMU unit with Optical Line Termination Equipment, Digital Multiplexer, hardware accessories etc. along with approach optical fibre (as per requirement from JB to ODF box), necessary interfacing and its integration work (at Inaruwa & LDC Kathmandu) for onward transmission of Data and Voice communication up to LDC Kathmandu is included in the contract. The details communication scheme of the same shall be attached in the drawings given with this specification.

18) **SCADA Integration**

All the online monitoring equipment i.e. Optical Temperature Sensors & Measuring Unit, Online Dissolved Gas (Multi-gas) and Moisture Analyzer, On-line insulating oil drying system (Cartridge type) provided for individual transformer and reactor unit including spare (if any), are IEC 61850 compliant (either directly or through a Gateway). These monitoring equipment are required to be integrated with SAS through managed Ethernet switch conforming to IEC 61850. This Ethernet switch shall be provided in MB by the contractor. The switch shall be powered by redundant DC supply (220V DC). Ethernet switch shall be suitable for operation at ambient temperature of 50 Deg C. All required power & control cables including optical cable, patch chord (if any) up to MB shall be in the scope of contractor. All cable from Digital RTCC to MB shall also be in the scope of contractor. Further, any special cable between MB to switchyard panel room/control room shall be in the scope of contractor. However, fiber optic cable, power cable, control cables, as applicable, between MB to switchyard panel room/control room and power supply (AC & DC) to MB and integration of above said IEC-61850 compliant equipment with Substation Automation System shall be under the scope of sub-station contractor.

Augmentation and integration work related to SCADA System

The 400/220kV bays under present scope at Hetauda substation shall be integrated by the contractor into existing SCADA system of Siemens 'SINAUT Spectrum"(version 4.3.2) installed at Master Station i.e. Nepal Electricity Authority Load Dispatch Centre (located in Siuchatar, Kathmandu). The integration shall include all hardware and software required at the Control Centre as well as necessary data base, display generation and upgrades for proposed control and monitoring of station and Network Analysis. The above activities shall be carried out as appropriate, in all of the 4 stations viz. New Dhalkebar, New Inaruwa, New Hetauda and the Load Dispatch Centre. The manufacturers of the existing SCADA system is Siemens Germany. The existing communication protocol used for SCADA at LDC Kathmandu is IEC 101. In the present scope of work, the data for SCADA purpose shall be obtained from the Substation Automation System (based on IEC 61850) using Gateway port with communication protocol IEC 101/104 or as per requirement being provided at Hetauda.

19) Complete relay and protection system for 400kV bays (Line bays, reactor bays, ICT Bays and Tie Bays), 220 kV ICT bays, 33 kV Station Transformer bay are under present scope as per Chapter –Control and Relay panels.

20) Fire protection system (HVW spray & hydrant system) for three (3) nos. of 400/220/33 KV, 315 MVA, 3-Ph Autotransformers and 1nos. 420kV, 50MVAR Reactors including extension of main water header (available at under construction Fire Fighting Pump House). The HVWS system shall be tapped from the Existing fire water system. The tapping point location & Existing firefighting system piping layout shall be provide to the successful bidders during detail engineering. FFPH & water Tank are not envisaged in the present scope of Contract.

21) 1.1kV grade Power & Control Cable along with complete accessories to complete the scope of works.

22) The earth mat for GIS earthing and the yard earthing required as per specification is in the bidder scope. The earth mat already exist in the 220 kV switchyard area. All the AIS/GIS equipments, Transformer, Reactors shall be earthed and this earth mat shall be connected to the Existing 220 kV earth mat by the contractor. Any additional earthing materials required shall be in the present scope of work.

23) Lattice and pipe structures (galvanized): Standard lattice gantry structures (400/220/33 kV Beams, Towers and Lightening Mast), pipe/lattice support structure for equipment (pipe structures shall be used for 220 & 400 kV

equipment support) and Structures for PEB Building, AHU room, relay panel room, battery & battery charger room and store/maintenance room etc. shall be prepared by the contractor and put up for approval of NEA during detailed engineering.

24) Complete lighting and illumination of switchyard under present scope of work.

25) Visual monitoring system for watch and ward of Substation premises as per Annexure-V.

26) EOT Crane as per technical specification is proposed in the GIS Building for handling and subsequent maintenance of GIS equipment. The bidder is required to keep the weight & size of the packages accordingly. Slings of required capacity for handling of GIS equipment/components shall be provided by the supplier. Embedment/Block outs, if any to be provided shall be considered and provided by the bidder. The bidder shall furnish his views regarding the proposed capacity of the crane.

27) LT switchgear (AC/DC Distribution boards).

As presently there were two incomer from the two 33/0.4 kV, 630 kVA LT Transformer. Under the present scope, the incomer -2 of the Main Switch Board shall be feed from the existing 33/0.4 kV, 630 kVA station transformer connected to the tertiary of Auto Transformer. The necessary extension/augmentations to complete the scope of works for Main Switch Board(MSB), AC Distribution Board (ACDB), Main Lighting Distribution Board (MLDB), Emergency Lighting Distribution Board (ELDB) and Power Kiosk as required is in present scope of work. Automatic changeover between Incomer-1, Incomer-2 and DG set is to be carried out during the failure of supply in one/or both the incomers additionally shall be installed as per present scope of contract. If necessary extension/augmentations of the existing AC Distribution Board (ACDB), Main Lighting Distribution Board (MLDB), Emergency Lighting Distribution Board (ELDB) and Power Kiosk is not possible, complete new panels shall be installed and deem to be included in the present scope of works. The details SLD of Existing AC system shall be provided during the details engineering stage.

28) Batteries & Battery Chargers

The capacity of Battery & Battery charger shall be worked out by the bidder for complete 400kV substation scope including future bays as shown in the Single line diagram. For Battery sizing calculations, DC drives shall be considered for future 400kV GIS modules. However minimum battery size for 220 V battery shall be 600 AH and for 48 V battery shall be 600 AH. The necessary DCDB is also in the present scope of work.

29) Any other equipment/material required for completing the specified scope.

30) Design, engineering, manufacture, testing, and supply on FOR destination basis Including transportation & insurance, storage at site.

31) **Civil works - The scope of work shall include but shall not be limited to the Following–**

Design, Engineering and civil work (as per Contractor supplied drawings) for:

a) PEB GIS Building for 400kV. The size of 400kV GIS Building shall be suitable to accommodate three complete diameter bays in addition to the maintenance bay. The AHU room, relay panel room, battery & battery charger room and store/maintenance room etc. shall be provided for as a part of PEB GIS Building. Necessary provision for future expansion shall be made in GIS Hall.

b) Foundation for GIS Hall Building and DG Enclosure.

c) Foundation for GIS bus duct supporting structures inside and outside the GIS hall.

d) Foundation for 3 nos. of 400/220/33 KV, 315 MVA, 3-Ph Autotransformers and 1nos. 420kV, 50MVAR Reactors along with jacking pad, rail tracks, pylon supports to complete the scope of works.

e) Fire resistant wall between Transformer/Reactors as per enclosed GA drawing.

f) Foundation for GIS equipment, GIS (SF6) to Air bushing, GIS (SF6) to Oil bushing, & supporting structure.

g) Cable trenches inside GIS hall, panel room, control room and DG room.

h) Cable trenches along with covers, road/rail crossings, sump pits and cable trench crossings with roads or drains etc.

i) All roads as shown in GA drawing including culverts. The roads shall be of RCC type.

j) Antiweed treatment, PCC and Stone spreading in switchyard area under present scope.

k) Drains along with drain crossings with cable trenches. Drain layout shall be developed by the contractor. Fencing for switchyard and switch yard gates. Dismantling/re-erection of existing fence as per requirement is also included.

l) Layout and details of Water supply (including bore well) and Sewage system complete as per technical specification.

m) As per the Soil Investigation works carried at 400 kV substation site, liquefaction susceptibility is seen up to 7.0m depth. To avoid the same, gravel pile/stone columns at specified spacing shall be provided beneath the foundation of structures up to 7.0 m deep from virgin soil for the stabilization of the structure/building foundation area as per the technical specification is also included in the present scope of works.

The soil investigation report already carried out at 400 kV switchyard area are included along with this tender. However, bidder shall carry out Electrical Resistivity Test of the present area of works are included in the present scope of works.

n) Site survey, contouring, leveling and filling. The leveling and filling (to an approximate depth of 1.0 to 2.0 mtrs) in the area under present scope of work inside substation is to be carried out to achieve finished ground level. The finished ground level shall be provided during detail engineering. However, as minimum, all GIS Hall Building, Control room building etc. are kept **0.5M** above the Finished Ground Level.

o) Foundation for lighting poles, Bay marshalling box, panels and control cubicles of equipments wherever required shall be as per design and drawings of contractor vendor drawings.

p) Slope protection of the filling area as per technical specification shall be also included in the present scope of works.

4.0 The Bidders are advised to visit the substation site and acquaint themselves with the topography, infrastructure and also the design philosophy. Before proceeding with the construction work in the existing substation, the Contractor shall fully familiarize himself with the site conditions and General arrangements & scheme etc. Though the Employer shall endeavor to provide the information, it shall not be binding the Employer to provide the same. The bidder shall be fully responsible for providing all equipment, materials, system and services specified or otherwise which are required to complete the construction and successful commissioning, operation & maintenance of the substation in all respects. All materials required for the Civil and construction/installation work including cement and steel shall be supplied by the Contractor.

The complete design (unless specified otherwise in specification elsewhere) and detailed engineering shall be done by the Contractor based on conceptual tender drawings.

5.0 The Contractor shall also be responsible for the overall co-ordination with internal/external agencies; Supplier of Employer's supplied equipments, project management, training of Employer's manpower, loading, unloading, handling, moving to final destination for successful erection, testing and commissioning of the substation/switchyard.

The Contractor shall be responsible to select and verify the route, mode of transportation and make all necessary arrangement with the appropriate authorities for the transportation of the equipment. The dimension of the equipment shall be such that when packed for transportation, it will comply with the requirements of loading and clearance restrictions for the selected route. It shall be the responsibility of the contractor to coordinate the arrangement for transportation of the Transformers for all the stages from the manufacturer's work to site.

The conditions of roads, capacity of bridges, culverts etc. in the route shall also be assessed by the bidders. The scope of any necessary modification/ extension/ improvement to existing road, bridges, culverts etc. shall be included in the scope of the contractor and deem to be included in the contract price. The contractor shall carry out the route survey along with the transporter and submit the detail proposal and methodology for transportation of transformers and reactor for approval of Employer within three months from the date of award.

6.0 The contractor shall arrange all T&P (such as necessary supports, cranes, ladders, platforms etc.) for erection, testing & commissioning of the system at his own cost. Further all consumables, wastages and damages shall be to the account of the contractor.

7.0 Contractor shall make his own arrangement at his own cost for the construction water supply along with all further distribution for the same. In any case, Owner shall not be responsible for any delay in works because of non-availability or inadequate availability of water.

8.0 Contractor shall make his own arrangement at his own cost for the storage of the materials. In any case, Owner shall not be responsible for non-availability storage area inside the substation boundary. Contractor shall maintain separate register for all certificates of Inspection (CIP) and Material Inspection Clearance Certificates (MICC) issued by NEA/Consultant. For each issue of CIP/MICC a serial number will be given and it shall be recorded by inspection engineer on CIP clearances/MICC.

9.0 Design of substation and its associated electrical & mechanical auxiliaries systems includes preparation of single line diagrams, electrical layouts, Erection key diagrams, direct stroke lightning protection, electrical and physical clearance diagrams, control and protection schematics, wiring and termination schedules, foundation & cable trench layout drawing including associated invert levels, civil designs **(as applicable)** and drawings, firefighting protection and ventilation, air conditioning system, lighting/illumination and other relevant drawings & documents required for engineering of all facilities within the fencing to be provided under this contract, are covered under the scope of the Contractor.

10.0 Any other items not specifically mentioned in the specification but which are required for Erection, Testing and Commissioning and satisfactory operations of the substation are deemed to be included in the scope of the specification and the same shall be supplied and erected by the contractor unless specifically excluded elsewhere.

11.0 SPECIFIC EXCLUSIONS

The following items of work are specifically excluded from the scope of the specification:

(a) Employer's site office and stores.

(b) Approach Road up to Substation boundary

(c) Boundary wall along substation

12.0 PHYSICAL AND OTHER PARAMETERS

12.1 Location of the Substation – The location of substation is indicated below:

All two substations (Inaruwa & Hetauda) of Nepal Electricity Authority are located near East – West Highway Road. For the purpose of transportation of goods, boarder entry points (with India) are Jogbani for Inaruwa S/S and Raxaul for Hetauda.

Meteorological data:-

a) Altitude above sea level :

i) Hetauda – 474m, ii) Inaruwa – 81m

b) Ambient Air Temperature :

i) Hetauda – 36.5ºC(max)/7.2ºC(min)

ii) Biratnagar-35.6ºC(max)/ 8.2ºC(min) Near Inaruwa

c) Average Humidity (in %) :

i) Hetauda – 94.62(max),53.5(min) ii) Biratnagar(near Inaruwa) – 96.72(max), 43.58(min)

d) The substation locations are lying in the wind speed Zone 4 i.e. 47m/s.

e) Seismic Requirement for Substations: 0.5g (Horizontal peak acceleration value).

The above specification are applicable for all the equipment, structures and Buildings.

13.0 SCHEDULE OF QUANTITIES

The requirement of various items/equipments and civil works are indicated in Schedules of Rates and Prices.

All equipments/items and civil works for which bill of quantity has been indicated in Schedules of Rates and Prices) shall be payable on unit rate basis/quoted rate basis. During actual execution, any variation in such quantities shall be payable as per relevant clauses incorporated in Letter of award.

Wherever the quantities of items/works are not indicated and quantified (i.e. Lump sump or lot items) the bidder is required to estimate the quantity required for entire execution and completion of works and incorporate their price in respective Schedules of Rates and Prices. For erection hardware items, Bidders shall estimate the total requirement of the works and indicate module-wise lump sum price bay wise and include the same in relevant Schedules of Rates and Prices under contractor assessed quantities. For module identification, Bidder may refer typical drawings enclosed with the specifications. Any material/works for the modules not specifically mentioned in the description in Schedules of rates and prices, as may be required shall be deemed to be included in the module itself.

The detailed bill of quantities of the mandatory spares for which break up is not given in the bid price Schedules are indicated at Annexure-I of this part.

The quantities specified in the Schedules of Rates and Prices are only estimates. As soon as practicable, the Contractor shall complete all survey, design and investigation works and accordingly revise the quantities and the Schedules of rates and Prices based on the unit/lump sum prices quoted in the Schedules of rates and Prices to complete the Facilities in accordance with the Technical Specifications and submit for Employer's approval. The revised price adjustment due to variation of quantities shall be limited to ±15% of the initial contract amount for the total amount of the respective schedules.

Bidder should include all such items in the bid proposal sheets, which are not specifically mentioned but are essential for the execution of the contract. Item which explicitly may not appear in various schedules and required for successful commissioning of substation shall be considered included in the bid price and shall be provided at no extra cost to Owner.

14.0 BASIC REFERENCE DRAWINGS

14.1 The substations under present scope have the following Switching Schemes

Sl. No.	Name of Substation	400kV Switching Scheme	220kV Switching Scheme
1	400/220kV Hetauda and Inaruwa S/S	One & half Breaker (GIS)	Double Main & Transfer (DMT) (AIS)

14.2 Single line diagram and general arrangements are enclosed with the bid documents for reference, which shall be further engineered by the bidder. The enclosed drawings give the basic scheme, layout of substation, substation buildings, associated services etc. In case of any discrepancy between the drawings and text of specification, the requirements of text shall prevail in general. However, the Bidder is advised to get these clarified from Owner.

15.0 DIFFERENT SECTIONS OF TECHNICAL SPECIFICATION

15.1 For the purpose of present scope of work, technical specification shall consist of following sections and they should be read in conjunction with each other.

Chapter 1: Project Specific Requirements (PSR)
Chapter 2: General Technical Requirements (GTR)
Chapter 3: Gas Insulated Switchgears (GIS)
Chapter 4: Outdoor Switchgear
Chapter 5: Auto Transformers
Chapter 6: Bus Reactor
Chapter 7: LT Switchgears
Chapter 8: LT Transformers
Chapter 9: Lighting System
Chapter 10: Air Conditioning System
Chapter 11: Fire Protection System
Chapter 12: Power and Control Cable
Chapter 13: Battery and Battery Chargers
Chapter 14: Switchyard Erection
Chapter 15: Structure
Chapter 16: Civil Works
Chapter 17: Control Relay and Protection Panels
Chapter 18: Substation Automation
Chapter 19: Telecommunication Equipments
Chapter 20: Diesel Generator Set
Chapter 21- HV & EHV XLPE cable
Chapter 22: Technical Data Sheet (TDS)
Chapter 23: Drawings

15.2 In case of any discrepancy between Chapter 1-PSR, Chapter 2-GTR and other technical specifications on scope of works, Chapter 1- PSR shall prevail over all other Chapter.

15.3 In case of any discrepancy between Chapter 2-GTR and individual Chapter for various equipments, requirement of individual equipment chapter shall prevail.

16.0 Mandatory Spares

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 BPS and shall be considered for evaluation of bid. It shall not be binding on the purchaser to procure all of these mandatory spares.

No mandatory spares shall be used during the Commissioning of the equipment. Any spares required for Commissioning purpose shall be arranged by the Contractor. The unutilized spares if any brought for Commissioning purpose shall be taken back by the contract.

17.0 SPECIAL TOOLS AND TACKLES

The bidder shall include in his proposal the deployment of all special tools and tackles required for erection, testing, commissioning and maintenance of equipment. However a list of all such devices should be indicated in the relevant schedule provided in the BPS. In addition to this the Contractor shall also furnish a list of special tools and tackles for the various equipment in a manner to be referred by the Employer during the operation of these equipment. The scope of special tools and tackles are to be decided during detail engineering and the list of special tools and tackles, if any shall be finalized.

18.0 FACILITIES TO BE PROVIDED BY THE EMPLOYER

i. Owner shall make available the auxiliary HT power supply (either 11 kV or 33 kV) from NEA on chargeable basis at a single point in the Sub-station. The prevailing energy rates of the state shall be applicable. Necessary stations transformers, metering equipment along with all further distribution from the same for construction supply shall be made by the contractor. However, in case of failure of power due to any unavoidable circumstances, the contractor shall make his own necessary arrangements like diesel generator sets etc. at his own cost so that progress of work is not affected and Owner shall in no case be responsible for any delay in works because of non-availability of power.

19.0 SPECIFIC REQUIREMENT

1) The Bidders are advised to visit Substation site and acquaint themselves with the topography, infrastructure, etc.

2) The bidder shall be responsible for safety of human and equipment during the working. It will be the responsibility of the Contractor to co-ordinate and obtain Electrical Inspector's clearance before commissioning. Any additional items, modification due to observation of such statutory authorities shall be provided by the Contractor at no extra cost to the Employer.

3) The lighting fixtures for switchyard lighting shall be mounted on LMs wherever LMs are provided. Where LMs are not available, the fixture may be mounted on Gantry structures or on lighting poles to be provided by the contractor.

4) Erection, Testing and Commissioning of Transformers, GIS, Circuit Breaker, Isolators, Relay & protection panels, sub-station automation system and Communication System shall be done by the contractor under the supervision of respective equipment manufacturers. Such supervision charges shall be included by the bidder in the erection charges for the respective equipment in the Bid Price Schedule (BPS). Further, after operational acceptance of the facilities under the contract, contractor shall provide the manufacturer warranty certificate with contact details of manufacturer in the name of Employer for the major critical components (Gas Insulated Switchgears, Auto Transformers, Reactors, Control Relays, SAS and communication equipment) for the period of five (5) years after the date of operational acceptance without any financial implication to NEA.

5) The fault level of all equipment to be supplied under present scope shall be as indicated below:

S.N.	Voltage Level	Fault Level
1	400kV	50kA for 1 Sec
2	220kV	40kA for 1 Sec
3	132kV	31.5kA for 1 Sec
4	66kV	31.5kA for 1 Sec
5	33kV	25kA , 1 sec
6	11 kV	25kA , 1 sec

6) The GIS halls will be illuminated using enclosed type high bay, luminaries having 1X250 watt (for 400kV & below voltage level GIS hall), metal halide fixtures with approximately 1(one) fixture per 20 square meter. Approximately (10) ten numbers Surface mounted 1x 8W bulkhead LED lights shall be provided for the emergency areas, the location of the same shall be decided during detailed engineering. GIS halls shall also be provided with at least two (2) nos of occupancy sensors subject to provision of at least one sensor per 100 sqm to control the lighting. The illumination in the panel room

wherein all the relay, protection and Teleprotection panels shall be located will have LED luminaries as specified in section Lighting System.

7) The Contractor shall impart the necessary training to Owner's Personnel as per following details:-

7.1 Training at Manufacturer's works. The Contractor shall include in the training charges NEA trainees' lodging, meals, local transportation, training materials, to and fro economy class air ticket from Nepal to place of training and payment of USD 150 per Diem allowances per trainee per day for the duration of training..

The training shall be provided in the field of design, testing and maintenance at Manufacturer's works as per following:-

1. Control & Protection, Substation Automation System and Communication System: 10 Days

   (3Nos. Trainees)

2. GIS Equipments and System (Circuit Breaker, Isolator, CT, CVT & LA) and EHV GIS/AIS Substation Design :10 Days

   (3 Nos Trainees)

3. EHV GIS/AIS Substation Design :10 Days

   (3 Nos Trainees)

7.2 On Job Training in Nepal: The traveling and living expenses of Owner's personnel for the training programme conducted in Nepal shall be borne by the Owner. The training shall be provided to Employer's personnel in the field of erection, testing, operation and maintenance at substation site as per following:-

1. Control & Protection: 5 Days.
2. Substation Automation System including integration aspect of existing SCADA (of Siemens supplied SINAUT spectrum) at Load Dispatch Centre: 5 days.
3. Indoor GIS and Outdoor Switchyard Equipments (CT, CVT, Isolator and Circuit Breaker) Operation and Maintenance: 5 days.
4. Operation and Maintenance of Transformer & Reactors: 5 Days

8) All RCC shall be of M-25 grade (Minimum) with mixed design conforming to relevant BS/IS/international standard. All Reinforcement steel shall be of FE-500(Minimum) grade conforming to BS/IS/ international standard.

9) The Frequency range for the earthquake spectra shall be as per IEC-62271-300.

10) Transmission line side insulator String (including Hardware) i.e. tension insulator on the substation side of the takeoff gantry for 400kV lines termination is under the present scope of specification.

11) The short description has been used in the bid price schedule. The details of all such short description are given in the respective chapter of this specification. The bidder shall refer these detailed descriptions for clarity.

12) One number each Energy meter for the record and revenue purpose is to be provided for each 400/220 bays under present scope of contract, meeting the requirement as specified at Annexure- III.

13) Non CFC refrigerant shall be utilized for Air conditioning system, under the scope of contract.

14) The contractor may have option to use post installed anchor bolts of reputed manufacturer for fixing GIS Bus ducts and modules in place of normal pre-installed Anchor bolts without any cost implication to NEA. The type & thickness of galvanization such post installed anchor bolts shall be as per manufacturer's practice.

15) Suitable oil tank for transformer oil shall be provided by the Contractor at his own cost. Oil tanks can be taken back by the Contractor after commissioning of transformers at new locations.

16) Dimension and color of C&R panels at all the existing switchyards shall match with existing panels.

17) One set 3½C x 300 Sq. mm XLPE power cable for oil filtration units shall be provided for 400/220kV Transformer/400kV Reactor. The cable shall be terminated at 250A receptacle near 400/220kV Transformer/400kV Reactor in the switchyard. XLPE Power cables shall be looped in & out for 250A Power receptacles.

18) The distance protection relays to be supplied for 400kV lines should have feature of load encroachment blinder to safeguard the protection trip during heavy load condition.

19) Separate protection relay (IED) shall be provided for 400kV Class Transformer directional over current and earth fault relay (for both HV & MV side). Inbuilt function in any other protection IED / BCU is not acceptable.

20) In the Sub-station automation system, each gas tight compartments of 400kV GIS shall be monitored individually per phase basis. In case it is not possible to monitor the gas tight compartment individually in one BCU, the contractor shall supply additional BCU for the monitoring without any additional cost implication to NEA.

21) For supply of SF6 Gas, the contractor shall obtain necessary license from the concerned statuary authorities in Nepal. The contractor shall comply with all the

legal & statuary requirements as per the local laws for importing, handling & storage of SF6 gas in Nepal. For this purpose NEA shall extend necessary assistance (documentation etc) for obtaining such clearance & licenses, however the complete responsibility for submitting the application and co-ordination with authorities shall be in the scope of contractor.

22) The Empty gas Cylinders may be taken back by the contractors after filling the gas in GIS compartments. However, in view of the future maintenance requirement, the contractor shall provide the Gas storage capacity equivalent to the Gas used in largest Gas tight GIS Module. Further, the spare Gas shall be supplied in Gas storage cylinders.

20.0 PRECOMMISSIONING, COMMISSIONING, TRIAL-RUN & COMPLETION

As soon as the Facilities covered by these specifications are physically completed in all respects, the Pre-commissioning, Commissioning, Trial-run and Completion of the Facilities, as mentioned below, shall be attained in accordance with the procedure given in the Conditions of Contract, Vol-I of the Bidding Documents.

(i) Pre commissioning : As per relevant Sections

(ii) Commissioning : Charging of the Facilities at rated voltage.

Further, wherever appearing in these specifications, the words – 'commissioning checks', 'installation checks', 'site tests', 'performance guarantee tests for fire protection system', are to be considered as 'pre commissioning checks'.

(iii) Trial-run : Operation of the Facilities or any part thereof by the Contractor immediately after the Commissioning for a continuous period of 72(Seventy two) hours continuously. In case of interruption due to problem /failure in the respective equipment, the contractor shall rectify the problem and after rectification, continuous 72(Seventy two) hours period start after such rectification.

(iv) Completion: Upon successful completion of Trial-run.

'Guarantee Test(s)' and/or 'Functional Guarantees' are applicable only for Substation Automation System as specified in Section-'Substation Automation System.'

Annexure-I

List of Mandatory Spares Parts

S.N.	Item Description	Unit	Quantity	
			Hetauda	Inaruwa
A	**Spare for 400kV GIS**			
1	**General**			
1.10	SF6 gas Pressure Relief Devices, 3 Nos. of each type	Set	2	2
1.20	SF6 Pressure gauge with coupling device cum switch or density monitors and pressure switch as applicable (1 no of each type)	Set	1	1
1.30	Coupling device for pressure gauge cum switch for connecting Gas handling plant	Set	2	2
1.40	Rubber Gaskets, "O" Rings and Seals for SF6 gas of each type	Set	1	1
1.50	Molecular filter for SF6 gas with filter bags	Set	20% of total weight	20% of total weight
1.60	All types of Control Valves for SF6 gas of each type	Set	2	2
1.70	SF6 gas	LS	20 % of total gas	20 % of total gas
1.80	All types of coupling for SF6 gas (1 no. of each type)	Set	1	1
1.90	Pipe length (Copper or Steel as applicable) for SF6 Circuit of each type	Set	1	1
1.10	Density Monitors for SF6 Gas	No	1	1
1.11	**Covers with all accessories necessary to close a compartment in case of dismantling of any part of the Enclosure to ensure the sealing of this compartment**			
1.11.1	For 3 phase enclosure if applicable	No	2	2
1.11.2	For 1 phase enclosure if applicable	No	3	3
1.12	Locking device to keep the Dis-connectors (Isolators) and Earthing switches in close or open position in case of removal of the driving Mechanism	Set	1	1
1.13	Bus support Insulator of each type for single phase/3 phase enclosure	No	5% of population	5% of population
1.14	SF6 to air bushing (400KV) of each type &	Set	1	1

S.N.	Item Description	Unit	Quantity	
			Hetauda	Inaruwa
	rating			
1.15	Spares for Local control cabinet including MCB, fuses, timers, Aux Relay of each type & rating terminal of each type	Set	1	1
2	**For 400 kV Circuit Breaker**			
2.10	Complete Circuit Breaker pole of each type & rating complete with interrupter, main circuit, enclosure and Marshalling Box with operating mechanism	Set	3	3
2.20	Fixed, moving and arcing contacts including insulating nozzles 3 Nos. of each type	Set	1	1
2.30	Rubber gaskets, `O' rings and seals for SF6 gas of each type	Set	1	1
2.40	Trip coil assembly with resistor as applicable, 3 Nos. of each type	Set	2	2
2.50	Closing coil assembly with resistor as applicable, 3 Nos. of each type	Set	2	2
2.60	Molecular filter for SF6 gas with filter bags	LS	10% of quantity	10% of quantity
2.70	SF6 Pressure gauge cum switch or Density monitors and pressure switch as applicable, 3 nos each type	Set	1	1
2.80	Coupling device for pressure gauge cum switch for connecting Gas handling plant, 3 Nos. of each type	Set	1	1
2.90	Relays, Power contactors, push buttons, timers & MCBs etc of each type & rating	Set	1	1
2.10	Closing assembly/ valve, 3 Nos. of each type 1 No.	Set	2	2
2.11	Trip assembly/ valve, 3 Nos. of each type 1 No.	Set	2	2
2.12	Aux. switch assembly, 3 Nos. of each type	Set	1	1
2.13	Operation Counter, 3 Nos. of each type 1 No.	Set	1	1
2.14	Rupture disc, 3 Nos. of each type 1 no.	Set	1	1
2.15	Windoscope/Observing window, 3 Nos. of each type	Set	1	1

S.N.	Item Description	Unit	Quantity	
			Hetauda	Inaruwa
2.16	Spring operated closing mechanism, 1 No of each type, if applicable	Set	1	1
2.17	**Hydraulic Operating Mechanism, if applicable**			
2.17.1	Hydraulic operating mechanism with drive motor , 3 Nos of each type	Set	1	1
2.17.2	Ferrules, joints and couplings, 3 Nos. of each type	Set	1	1
2.17.3	Hydraulic filter, 3 Nos. of each type	Set	1	1
2.17.4	Hose pipe, 3 Nos. of each type	Set	1	1
2.17.5	N2 Accumulator, 3 Nos. of each type	Set	1	1
2.17.6	Pressure transducer, 3 Nos. of each type	Set	1	1
2.17.7	Valves 3 Nos. of each type	Set	1	1
2.17.8	Pipe length (copper & steel) 3 Nos. of each size & type	Set	1	1
2.17.9	Pressure switches 3 Nos. of each type	Set	1	1
2.17.10	Pressure gauge with coupling device, 3 Nos. of each type	Set	1	1
2.17.11	Hydraulic oil -20% of total requirement	Set	1	1
2.17.12	Pressure Relief Device, 3 Nos. of each type	Set	2	2
3	**400 kV ISOLATORS**			
3.10	Complete set of 3 nos. of single phase / one no. of 3-phase dis-connector including main circuit, enclosure, driving mechanism	Set	1	1
3.20	High speed/Fast acting fault making grounding switch 3 nos of single phase /1 no of 3-phase of each voltage rating including main circuit , enclosure and driving mechanism	Set	1	1
3.30	3 no. of single phase / one no of 3-phase Earthing switch including main circuit, enclosure, driving mechanism	Set	1	1
3.40	Copper contact fingers for dis-connector male & female contact –for one complete (3 phase) dis-connector of each type and rating	Set	1	1
3.50	Copper contact fingers for earthing switch male & female contacts- for one complete (3 phase) earthing switch of each type and	Set	1	1

S.N.	Item Description	Unit	Quantity	
			Hetauda	Inaruwa
	rating			
3.60	Open / Close contactor assembly, timers, key interlock for one complete (3 phase) dis-connector and (3 phase) earthing switch of each type and rating	Set	1	1
3.70	Push button switch.-each type, as applicable	Set	1	1
3.80	**Limit switches and Aux. Switches for complete 3 phase equipment**			
3.8.1	For isolator	Set	3	3
3.8.2	For earth switch	Set	1	1
3.90	**Rotor housing bearing assembly for complete 3 phase equipment**			
3.9.1	For isolator	Set	2	2
3.9.2	For earth switch	Set	1	1
3.10	**Motor with gear assembly for complete 3 phase equipment**			
3.10.1	For isolator	Set	3	3
3.10.2	For earth switch	Set	1	1
3.11	Corona shield rings as applicable	Set	1	1
3.12	**Hinge pins for complete 3 phase equipment**			
3.12.1	For isolator	Set	3	3
3.12.2	For earth switch	Set	1	1
3.13	**Bearings for complete 3 phase equipment**			
3.13.1	For isolator	Set	5	5
3.13.2	For earth switch	Set	1	1
3.14	Interlocking coil with resistors, timers, key interlock for complete 3 phase equipment (each type and rating)	Set	1	1
3.15	**Relays, Power contactors, resistors, fuses, push buttons, timers & MCBs (complete for one 3 phase equipment)**			
3.15.1	For isolator	Set	3	3
3.15.2	For earth switch	Set	1	1
3.16	Aux. switch assembly (complete) with 10 NO & 10 NC or more contacts for both isolator & earth switch	Set	1	1

S.N.	Item Description	Unit	Quantity	
			Hetauda	Inaruwa
4	**400 KV CURRENT TRANSFORMER**			
4.1	Gas Insulated Complete CT of each type and rating with enclosure.	No	2	2
4.2	Secondary bushing of each type	Set	2	2
5	**400kV Voltage Transformer**			
5.1	Gas Insulated Complete VT of each type and rating with enclosure	No	1	1
6	**336 kV Surge Arrester**			
6.1	Gas Insulated Complete SA, Surge Monitors with enclosure	No	1	1
7	420 kV, RIP (Specified Type- SF6 to air) bushing with metal parts and gaskets	No	1	1
B	**Spares for Other Equipments**			
1	**CVT (420 kV,8800 pF)**	No.	1	1
2	**216kV Surge Arrester**			
i)	Complete LA	No.	1	1
ii)	Surge counter/monitor	Nos.	4	4
3	**216kV Surge Arrester**		1	1
i)	Complete LA	No.	1	1
ii)	Surge counter/monitor	Nos.	4	4
4	**30kV Surge Arrester**			
i)	Complete LA	No.	1	1
ii)	Surge counter/monitor	Nos.	4	4
5	**Bus Post Insulators**	Nos.	1	1
i)	400 kV	No.	1	1
ii)	220 kV	Nos.	1	1
iii)	72.5 kV	Nos.	1	1
iv)	36 kV	Nos.	1	
6	**420 kV 50MVAR Bus Reactor**			
6.10	420 kV, 800 Amps, specified type bushing with metal parts and gaskets	No.	1	1
6.20	36 kV, 630 Amps bushing with metal parts and gaskets	No.	1	1
6.30	Local and remote WTI complete unit with sensing devices and contacts	Set	1	1
6.40	Local and Remote OTI complete unit with contacts and sensing bulbs	Set	1	1
6.50	Magnetic Oil Level gauge	No.	1	1

S.N.	Item Description	Unit	Quantity	
			Hetauda	Inaruwa
6.60	Pressure Relief Device	Nos.	2	2
6.70	Buchholz relay complete with float and contacts	No.	1	1
6.80	Flexible air cell	Sets	1	1
6.90	Neutral Current Transformer	Sets	2	2
7.00	Breather assembly	Sets	2	2
7.10	MCBs/MCCBs of each type used	No.	1	1
7.20	Sets of fuses of each type used	Sets	3	3
7.21	Fan Contactors used in the cooler control circuit of each type used	Nos.	2	2
7.22	Relays used in the cooler control circuit of each type used	Nos.	2	2
7.23	Indication lamps (one of each type)	Nos.	5	5
8	**Auto Transformers :**			
8.10	HV (420 kV), specified type bushings with gaskets etc.	No.	1	1
8.11	IV (245kV), specified type bushings with gaskets etc.	No.	1	1
8.12	LV (52kV) specified type bushings complete with gaskets etc.	No.	1	1
8.13	HVN(52kV) specified type neutral bushing complete with gaskets etc.	No.	1	1
8.14	Gaskets for all openings on Transformer tank.	Set	1	1
8.15	Oil and Winding Temperature Indicators.	Nos.	6	6
8.16	Magnetic oil level gauge.	No.	1	1
8.17	Pressure Relief Device.	No.	1	1
8.18	Oil pumps with motor & starter.	No.	1	1
8.19	Oil flow indicator.	Nos.	2	2
8.20	Contactors used in the cooler control circuit.	Nos.	6	6
8.21	Relays used in the cooler control circuit.	Nos.	6	6
8.22	Indication lamps assembly complete used in the Marshalling box/marshalling box.	Nos.	10	10
8.23	MCCBs/ MCBs used in Marshalling Box/RTCC/Panels	Nos.	6	6
8.24	Buchhloz Relay	Nos.	2	2

S.N.	Item Description	Unit	Quantity	
			Hetauda	Inaruwa
8.25	Valves of each type used	Nos.	2	2
8.26	Air cell	Nos.	1	1
8.27	Neutral CTs	Nos.	1	1
8.28	Switches/ Push Buttons used in the panels	Nos.	9	9
8.29	Heater used in the panels	Nos.	2	2
8.30	Thermostat used in the panels	Nos.	2	2
8.31	Terminal blocks used in the panels	Nos.	6	6
8.32	Relay for OLTC	Nos.	1	1
8.33	Drive Motor for OLTC with gear assembly	Nos.	1	1
8.34	Fuses used in panels	Nos.	9	9
8.35	Breather for Conservator tank	Nos.	3	3
8.36	Silicagel	kg	6	6
8.37	Oil Sampling bottle of stainless steel having capacity of 1 litre as per TS	Nos.	6	5
8.38	Oil Syringe as per TS	Sets	2	2
8.39	Hand Tools as per TS	Sets	1	1
8.40	BDV Kit	Sets	1	1
8.41	Portable DGA Kit	Sets	1	
9	**630 KVA Transformer**			
9.1	All Bushing with metal parts (each voltage rating) for 630 KVA Transformer	No	1	1
9.2	Oil Temperature Indicator with sensing device	Set	1	1
9.3	Tap Changer Contacts	Set	1	1
9.4	Buchhloz Relay	No	1	1
9.5	Explosion vent diaphragm	No	1	1
9.6	Set of valve (each type)	Set	1	1
9.7	3-Phase 11 kV Horn Gap Fusew	Set	1	1
10	**Relay and Protection Panel :**			
10.1	**Breaker Relay Panel**			
1	Breaker failure Relay	No	1	1
2	Trip/Close Circuit Supervision Relay	No	2	2
3	Self reset trip relay of each type (if applicable)	No	1	1
4	Auto Reclose relay with check synchronizing relay and dead line charging relay	No	1	1
5	Timer relay of each type (if applicable)	No	1	1

S.N.	Item Description	Unit	Quantity	
			Hetauda	Inaruwa
6	DC Supervision relays (if applicable)	No	1	1
7	Hand reset Trip Relay of each type (if applicable)	No	1	1
8	Flag relays of each type (if applicable)	No	1	1
9	Auxiliary relays of each type	No	1	1
10.2	**Line Protection Panel Equipment spare**			
1	Main-1 Numerical distance relay (excluding external trip relays) with software and cable for front panel communication to PC	Set	1	1
2	Main-2 Numerical distance relay with inbuilt distance relay (excluding external trip relays) with software and cable for front panel communication to PC	Set	1	1
3	Disturbance recorder comprising of evaluation & acquisition units with software (if stand alone)	Set	1	1
4	Distance to fault locator including mutual compensation units (if stand alone)	Set	1	1
5	Over voltage protection relays with timers (Stage-I & Stage-II) (If stand alone)	Set	1	1
10.3	**Transformer Protection Panel**			
1	Transformer overall differential protection relay including all aux. CTs (if applicable) , associated software and cable for front panel communication to PC (in case of numerical relay)	No	1	1
2	Restricted Earth Fault protection relay with non linear resistor (if applicable) and associated software in case of numerical relay	No	1	1
3	Back up protection relay with 3 O/C and E/F element and associated software in case of numerical relay	Set	1	1
4	Over fluxing relay (if stand alone)	Set	1	1
5	CVT fuse failure relay (if applicable)	Set	1	1
6	Over load relay with timer (if applicable)	Set	1	1
10.4	**Reactor Protection Panel**			

S.N.	Item Description	Unit	Quantity	
			Hetauda	Inaruwa
1	Reactor overall differential protection relay including all aux. CTs (if applicable) , associated software and cable for front panel communication to PC (in case of numerical relay)	No	1	1
2	Restricted Earth Fault protection relay with non linear resistor (if applicable) and associated software in case of numerical relay	No	1	1
3	Back up protection relay with 3 O/C and E/F element and associated software in case of numerical relay	Set	1	1
4	Over fluxing relay (if stand alone)	Set	1	1
5	CVT fuse failure relay (if applicable)	Set	1	1
6	Over load relay with timer (if applicable)	Set	1	1
10.5	**Common Spares**			
1	Power supply module for Bus Bar Protection	Set	1	1
2	Metrosil (Non Linear resistor) each type if applicable	Set	1	1
3	Inter-posing CTs & PTs each type	Set	1	1
4	Power Supply module of Event logger	No	1	1
5	Processor Card of Event logger	Set	1	1
10.6	**Substation Automation system**			
1	Bay control unit with associated software	No	1	1
2	Ethernet switch of each type	No	1	1
3	Longest optical cable with end terminations	Set	1	1
11	**Fire Fighting System**			
11.1	**General**			
11.1.1	Quartzoid bulb detector	No	10% of total population	10% of total population
11.1.2	Projectors(Nozzles)	No	10% of total population	10% of total population
11.1.3	Smoke detectors			
i)	Photo electric type	No	10% of total population	10% of total population
ii)	Ionisation type	No	10% of total population	10% of total population

S.N.	Item Description	Unit	Quantity	
			Hetauda	Inaruwa
11.1.4	Heat Detectors (for battery room)	No	10% of total population	10% of total population
11.1.5	Electrical Control Panel: Annunciation printed circuits (solid state annunciations) in Control Panel	Set	1	1
11.1.6	Strainer	Set	1	1
11.1.7	Deluge valve	No	1	1
11.1.8	Fire detection bulbs	No	10	10
11.1.9	Branch pipe fitted with nozzle & guide coupling	No	2	2
11.1.10	Hydrant Valve	No	1	1
11.1.11	Pressure switch	No	1	1
11	**Batteries and Battery Charger**			
11.1	**220 V Battary Bank**			
11.1.1	Spare Battery Cell	No	5	5
11.1.2	Terminal Connector with Nuts and Bolts	No	10	10
11.1.3	Float Level indicators	No	10	10
11.1.4	Vent Plugs	No	10	10
11.2	**48 V Battary Bank**			
11.2.1	Spare Battery Cell	No	5	5
11.2.2	Terminal Connector with Nuts and Bolts	No	10	10
11.2.3	Float Level indicators	No	10	10
11.2.4	Vent Plugs	No	10	10
11.3	**Battery charger (220V)**			
i)	Set of control cards	Set	1	1
ii)	Set of relays	Set	1	1
iii)	Rectifier transformer	No.	1	1
iv)	Thyristor/diode	Set	1	1
v)	Fuses of Thyristor with indicators	Set	6	6
11.4	**Battery charger (48V)**			
i)	Set of control cards	Set	1	1
ii)	Set of relays	Set	1	1
13	**LT SwitchGear**			
13.1	Relays	Set	1	1
13.2	CTs and PTs	Set	1	1
13.3	Switches/ Push buttons and Meters	Set	1	1
13.4.A	TPN Switches / MCB	Set	1	1

S.N.	Item Description	Unit	Quantity	
			Hetauda	Inaruwa
13.4B	MCCB of each rating	Set	1	1
13.5	LT Breaker Spares :			
13.5.1	Spring Charging motor	No	1	1
13.5.2	Aux. Contact sets	Set	2	2
13.5.3	Bus Bar seal off insulators	No	5	5
13.5.4	Arc Chutes	Set	2	2
13.5.5	Moving contacts	Set	1	1
13.5.6	Arcing contacts (Fixed/Moving)	Set	1	1
13.5.7	Springs(Closing/Opening)	No	1	1
13.5.8	Closing Coil	No	1	1
13.5.9	Tripping Coil	No	1	1
13.5.10	Aux. finger contact	Set	1	1
13.5.11	Limit Switches	Set	1	1
13.5.12	Jaw Contacts	Set	1	1
13.5.13	Bus Bar Insulators	No	5	5
13.5.14	Interphase Barrier	No	2	2
13.5.15	Bus Bar Stip 1 mm (Aluminium)	MTR	5	5
14	**Illuminations**	LS	5% of each type of lighting fixture supplied	5% of each type of lighting fixture supplied
15	**2 TR Split AC Units**			
15.1	High wall type split A/C System	Set	2	2
16	**Erection Hardware :**			
16.1	5% spares of the actual quantities for Insulator strings & hardwares, clamps & connectors (including equipment connectors), spacers, corona bell (No spares are to be considered for ACSR Moose conductor, 4" IPS Al tube, BMB, grounding conductors, cable tray, Pipes(GI/PVC/hume), angles, channels and Junction Boxes)	LS	1	1
17	**Telecommunication Equipments**			
A	**Transmission Equipment**			
A.1	**SDH Equipment (STM - 4/ STM-16 MADM, upto three MSP Protected directions)**			
a	Common cards, Power supply cards, power cabling, other hardware &	Set$	1	1

S.N.	Item Description	Unit	Quantity	
			Hetauda	Inaruwa
	accessories (each)			
b	**Optical Interface/SFP## for**			
i	L16.2 SFP	No.	1	1
ii	Optical Line Interface card (to support minimum 150 kms)***	No.	1	1
iii	Optical Line Interface card (to support minimum 175 kms)***	No.	1	1
c	**Tributary Cards**			
i	E1 Interface card (Minimum 16 interfaces per card)	No.	1	1
ii	Ethernet interfaces 10/100 Mbps with Layer-2 switching (Minimum 4 interfaces per card.)	No.	1	1
B	**Termination Equipment**			
a	**Drop/Insert Multiplexer Common cards, Power supply cards, power cabling, other hardware & accessories (each)**	Set	1	1
b	**Subscriber Line Interface Cards**			
i	2 wire (sub/sub) voice channel cards (min 8 channels per card)	No.	1	1
ii	4 wire (E&M) voice channel cards (min 8 channels per card)	No.	1	1
iii	Asynchronous Sub Channels data cards (minimum 4 channels per card)	No.	1	1
iv	Synchronous data card (NX64kbps)	No.	1	1
c	PMU Unit	Set	1	1
C	Pre Connectorized Optical Fiber Patch Cords (10 Mtrs) – Pack of Six Patch Cords	Set	1	1
D	2 wire local subscriber interface card for PABX	No.	1	1
E	E1 Interface card for PABX	No.	1	1
F	VOIP telephone instrument with one common switch (min. 4 port) including hardware and software as per specification	No	1	1
18.0	**245kV CB**			
i)	Complete Pole of circuit breaker including			

S.N.	Item Description	Unit	Quantity	
			Hetauda	Inaruwa
	pole column, interrupter, with driving mechanism and Marshaling Box but without support structure for			
	2500A, 40 KA (No. of Pole)	no		1
ii)	Rubber gaskets, `O' rings and seals (for complete replacement of one pole of CB)	set		1
iii)	Trip coils with resistor	nos		2
iv)	Closing coils with resistor	nos		1
v)	Terminal Pads & connectors	nos		2
vi)	Molecular filter	nos		2
vii)	Relays, Power contactors, switch fuse units, limit switches, push buttons, timers & MCB etc. (1 no. of each type)	set		1
viii)	Pressure switches / Density monitor (1 no. of each type)	set		1
ix)	Auxiliary switch assembly (for one pole of CB)	set		1
19.0	**72.5 kV CB**			
i)	Complete Pole of circuit breaker including pole column, interrupter, with driving mechanism and Marshaling Box but without support structure for			
	1250A, 25 KA (No. of Pole)	no	1	1
ii)	Rubber gaskets, `O' rings and seals (for complete replacement of one pole of CB)	set	1	1
iii)	Trip coils with resistor	nos	2	2
iv)	Closing coils with resistor	nos	1	1
v)	Terminal Pads & connectors	nos	2	**2**
vi)	Molecular filter	nos	2	**2**
vii)	Relays, Power contactors, switch fuse units, limit switches, push buttons, timers & MCB	set	1	**1**

S.N.	Item Description	Unit	Quantity	
			Hetauda	Inaruwa
	etc. (1 no. of each type)			
viii)	Pressure switches / Density monitor (1 no. of each type)	set	1	**1**
ix)	Auxiliary switch assembly (for one pole of CB)	set	1	**1**
20.0	**245kV Isolator**			
i)	One complete pole including support Insulator, motor operating mechanism (MOM) with box but excluding structure			
	1600A, 40 KA, 1 E/S (no. of pole)	no		1
ii)	Copper contact fingers for male & female contacts (for one pole of Isolator)	set		2
iii)	Open/Close contactor assembly, timers, key interlock push button switch & auxilliary switches (for one pole of Isolator)	set		1
iv)	Limit Switch	Nos.		2
v)	Terminal Pads & Connectors	nos		3
vi)	Corona shield rings	nos		3
21.0	**72.5 kV Isolator**			
i)	One complete pole including support Insulator, motor operating mechanism (MOM) with box but excluding structure			
	1250A, 25KA, 1 E/S (no. of pole)	no	1	1
ii)	Copper contact fingers for male & female contacts (for one pole of Isolator)	set	2	2
iii)	Open/Close contactor assembly, timers, key interlock push button switch & auxilliary switches (for one pole of Isolator)	set	1	1
iv)	Limit Switch	Nos.	2	2
v)	Terminal Pads & Connectors	nos	3	3
22.0	CT(245 kV,1600A with 120% extended current	No.		1

S.N.	Item Description	Unit	Quantity	
			Hetauda	Inaruwa
	rating)			
23.0	CT(72.5 kV, as specified rating)	No	1	
24.0	PT 72.5 kV	No	1	

Annexure-II

EXISTING SCADA & ITS DATA ACQUISITION

1.0 GENARAL INFORMATION

1.1 Data acquisition principles for existing Substation

The existing substations are provided with RTU for interfacing of the following supervisory controls and data acquisitions:

Remote Control

- Remote control of all 400/220/132/33kV circuit breakers.

Status indications

- Status indications of all 400/220/132kV circuit breakers, busbar and line isolators.
- Status indications of all 33kV line feeders.

1.2 Integration of SCADA of existing Substation

The 400/220kV bays under present scope at Dhalkebar substation shall be integrated by the contractor into existing SCADA system of Siemens 'SINAUT Spectrum"(version 4.3.2) installed at Master Station i.e. Nepal Electricity Authority Load Dispatch Centre (located in Siuchatar, Kathmandu). The integration shall include all hardware and software required at the Control Centre as well as necessary data base, display generation and upgrades for proposed control and monitoring of station and Network Analysis. The above activities shall be carried out as appropriate, in all of the 4 stations viz. New Dhalkebar, New Inaruwa, New Hetauda and the Load Dispatch Centre. The manufacturers of the existing SCADA system is Siemens Germany. The existing communication protocol used for SCADA at LDC Kathmandu is IEC 101. In the present scope of work, the data for SCADA purpose shall be obtained from the Substation Automation System (based on IEC 61850) using Gateway port with communication protocol IEC 101/104 as per requirement being provided at Dhalkebar.

Table 1.2: Alarms to be acquired from each type of bay

Type of Alarm	Line Bay	Transformer Bay	Coupler Bay	Busbar	Station
Main protection trip	MPT	MPT	MPT		
Back-up protection trip	BPT	BPT	BPT		
Bay fault	BFA	BFA	BFA		

Type of Alarm	**Line Bay**	**Transformer Bay**	**Coupler Bay**	**Busbar**	**Station**
Circuit breaker fault	CBF	CBF	CBF		
Auto-recloser operated	ARO				
Temperature Alarm		TAL			
Temperature Trip		TTR			
Buchholz alarm		BAL			
Buchholz Trip		BTR			
General transformer/reactor talarm		GTA			
General transformer/reactor Trip		GTT			
Busbar Voltage status				BVS	
Station urgent fault					SUF
Station none-urgent fault					SNF
Station Control disabled					SCD
RTU alarm					RTU
Communication alarm					COM
Total	**5**	**10**	**4**	**1**	**5**

Measurements

❖ Busbar voltages (separate for each busbar and section) of all 400/220/33 kV Busbars.

❖ Active/reactive power for

- All 400 kV Line feeders.
- All 400kV, 220kV and 33kV Transformer feeders.

Annexure-III

Specification for Revenue Meter & Metering (Instrument) Transformer

General

The units shall be suitable for operating in Outdoor environment and shall be manufactured by International Reputed ISO 9001 Company

Energy Meter

The Energy Meter shall have the following minimum requirement

Type	Electronic, 3Phase, 4wire, Wye Connection, Bi-directional
Accuracy Class	0.2
Applicable Standard	IEC 687 (latest edition) or Equivalent
Measurement	a) Polyphase Quantities kWh, kVARh, kVAh
	b) Instantaneous Quantities Real Time, kW, kVA, PF, Volts, Amps, Frequency
Rated Current (In)	5A or 1A
Rated Maximum Current	1.2xIn
Starting Current	0.001xIn
Voltage (Phase)	110V/√3
Frequency	50Hz
Programmable Interval length	At least 1 to 30 min
Load Profile Memory Storage	At Least 60 days of storage using 4 channels at 15min Intervals
Channels of Load Profile Data	At Least 4 channels of storage (kWh import, kWh export, kVARh Import, kVARh export)
Other Features to be Included	a) Serial communication port and Accessories b) Optical Port Communication (With optical Probe) c) Remote Download Modem (in built) d) Hardware Key to Prevent any Calibration and configuration change e) PT or CT error gain correction f) Non Volatile memory g) Inbuilt Super capacitor h) Meter shall be able to record and store in Non-Volatile memory the instant of Power failure and the instant of supply restoration.

Annexure-IV

A. SPECIFICATION FOR DIGITIAL PROTECTION COUPLER

1.0 Digital protection coupler for protection signalling through optical fibre cable system.

1.1 The Digital protection signalling equipment is required to transfer the trip commands from one end of the line to the other end in the shortest possible time with adequate security and dependability. It shall also monitor the healthiness of the link from one end to the other and give alarms in case of any abnormality. The protection signalling equipment shall have a proven operating record in similar application over EHV systems and shall operate on 48V DC (+10%, -10%). It shall provide minimum four commands. These commands shall be suitable for Direct tripping, Intertripping and Blocking protection schemes of EHV lines.

The protection signalling equipment shall communicate to the remote end interfacing with SDH terminal equipment at its 2Mbps port. It shall provide suitable interfaces for protective relays, which operate at 220/110V DC. Power supply points shall be immune to electromagnetic interface.

1.2 Principle of operation

During normal operation, protection signalling equipment shall transmit a guard signal/code. In case Protection signalling equipment is actuated by protective relays for transmission of commands, it shall interrupt the guard signal/code and shall transmit the command code to the remote end. The receiver shall recognize the command code and absence of the guard code and will generate the command to the protective relays.

All signal processing i.e. generation of tripping signal and the evaluation of the signals being received shall be performed completely digital using Digital Signal Processing techniques.

1.3 Loop testing

An automatic loop testing routine shall check the teleprotection channel.

It shall also be possible to initiate a loop test manually at any station by pressing a button on the front of the equipment.

Internal test routine shall continuously monitor the availability of the protection signaling equipment.

Proper tripping signal shall always take the priority over the test procedure.

The high speed digital protection signalling equipment shall be designed and provided with following features.

- Shall work in conjunction with SDH terminal equipment.
- It shall communicate on G 703 (E1,2 Mbps)
- Full Duplex operation
- Auto loop facility shall be provided
- Shall meet IEC 60834-1 standard
- Shall be able to transmit upto 4 commands with trip counter simultaneously or sequentially in one 2Mbps channel

Bidder shall quote for protection signalling equipment suitable for 4 commands with separate trip counters for transmit and receive. With regard to trip counters alternate arrangement .i.e. Laptop along with software & all accessories to download events including carrier receipt and transmit shall be acceptable. Laptop for the above shall be supplied at each substation under substation package.

High security and dependability shall be ensured by the manufacturer. Probability of false tripping and failure to trip shall be minimum. Statistical curves/figures indicating above mentioned measures shall be submitted along with the bid.

The DPC can be either housed in offered Control & Protection Panel / PLCC Panel or in separate panel.

Reports of the following tests as per clause 9.2 of Chapter 2-GTR shall be submitted for approval for protection signalling equipment and relays associated with the protection signalling equipment and interface unit with protective relay units, if any.

i) <u>General equipment interface tests</u> :

a) Insulated voltage withstand tests
b) Damped oscillatory waves disturbance test
c) Fast transient bursts disturbance test
d) Electrostatic discharge disturbance test
e) Radiated electromagnetic field test
f) RF disturbance emission test

ii) <u>Specific power supply tests</u>

a) Power supply variations
b) Interruptions
c) LF disturbance emission
d) Reverse polarity

iii) Tele-protection system performance tests

a) Security
b) Dependability
c) Jitter
d) Recovery time
e) Transmission time
f) Alarm functions
g) Temperature and Humidity tests (As per IEC 68-2)
- Dry heat test (50°C for 8 hours)
- Low temperature test (-5°C for 8 hours)
- Damp heat test (40°C/95%RH for 8 hours)

All the above tests at i, ii & iii (except temperature & humidity tests) shall be as per IEC 60834-1 and the standards mentioned therein.

iv) Relays

a) Impulse voltage withstand test as per IEC 60255.
b) High frequency disturbance test as per IEC 60255.

The protection signalling equipment shall be of modular construction and preferably mounted in the Relay panels. Cabling between the protection signalling equipment & Protection relays and between protection signalling equipment & Communication equipment shall be in the scope of bidder.

The input/output interface to the protection equipment shall be achieved by means of relays and the input/output rack wiring shall be carefully segregated from other shelf/cubicle wiring.

The isolation requirements of the protection interface shall be for 2kV rms.

1.4 Major technical Particulars

The major technical particulars of protection signalling equipment shall be as follows.

i) Power supply 48V DC +10%, -10%

ii) Number of commands 4 (four)

iii) Operating time <7 ms

iv) Back to back operate time without propagation delay ≤ 8 ms

v) Interface to Protection relays

Input: Contact Rating:

Rated voltage : 250 volts DC

Maximum current rating: 5 amps

Output: Contact Rating:

Rated voltage : 250 volts DC

Rated current : 0.1 A DC

Other parameters : As per IEC-255-0-20

vi) Alarm contact

Rated voltage : 250 volts DC

Rated current : 0.1 A DC

Other parameters : As per IEC-255-0-20

vii) Digital communication interface: G 703(E1)

B. TECHNICAL SPECIFICATION OF PABX EQUIPMENT

1.1 General

This section provides the functional and performance requirements for the PABX system. The Bidder is encouraged to propose any hardware configurations better suited to the characteristics of the Bidder's standard products as long as the equipment characteristic requirements of this specification are met.

The PABX must be capable of operating in the high EMI environment of substations and power plants, and without air conditioning. The bidder shall provided performance certificate from at least one customer for satisfactory operation of one year.

The Contractor shall be responsible for the installation and implementation of the PABX provided under this procurement along with the interfaces, associated hardware & accessories. This shall include the development of the database, system tests and training of Employer staff.

The following are the minimum requirements for PABX system.

1.2 Technical Requirement

The Contractor shall be responsible for providing state of the art TDM/PCM based PABX system. The offered PABX shall be modular in nature with universal slot architecture to facilitate future expansion requirements. Expansion shall require only procurement and installation of respective interface cards.

The exchange transmission performance shall comply with the ITU-T standards. The Contractor shall provide the details of standards conforming to the product supplied. The offered PABX must be capable of interfacing with 4-wire E&M VF channels provided by Power Line Carrier System (PLCC), E1 (G.703) / Ethernet channels provided by wideband communication equipment and 2 wire LS or 4 wire E&M channels provided by primary multiplexers. The PABX shall also be designed to operate over 2 wire leased telephone land line of other telecommunication provider.

All interfacing equipment necessary for satisfactory operation and to comply with the local regulation shall be provided under this procurement.

The Contractor shall ensure that the speech level and signal-to-noise ratio are satisfactory under all conditions likely to be encountered on the system. The offered PABX shall be integrated with existing PABXs. Any interfaces required for proper matching and connection with existing PABX equipment shall be provided by the Contractor. It shall support at a minimum the following features:

(a) SPC (Stored Program Control) type
(b) 100% non blocking switch with PCM-TDM
(c) Redundant processors or distributed processing architecture
(d) 2 Wire interfaces for local subscribers & remote subscriber
(e) 4 Wire E&M interfaces for two way trunks
(f) Extensions should be extendable over a distance of 300meters
(g) E1 Interface using Electrical (through copper cable) connection to existing SDH equipments.
(h) Provision of suitable interface for VOIP connectivity (50 Nos)
(i) Printer interface
(j) Extensions shall support DTMF & Pulse dial phones
(k) Extensions shall support analog phones/fax machines
(l) Ringer/Tone card for different tones and ring generation
(m) DID (Direct Inward dialing)
(n) DOD(Direct Outward dialing))

(o) Executive Override enabled
(p) Provision of Voice mail
(q) Call forwarding and Call pickup
(r) Circular hunting within a defined group
(s) Automatic call back
(t) Calling Line Identification Presentation (CLIP) support
(u) Howler tone for receiver-not-on-hook warning

The Contractor shall provide the suitable system for PABX configuration such as class of service, feature assignment, line and trunk access etc. Further, it shall be possible to make on-line changes to the database and shall be user friendly. In case, the bidder offers a PC based PABX configuration system, the PC/workstation shall be of reputed make (Compaq/HP/IBM/Dell) with 15” TFT Color monitor.

The Contractor shall install the telephone extensions as well as terminate the voice trunks along with requisite cable, PVC conduit/channels and other installation hardware. The PABX shall be supplied with a MDF which may be housed inside the PABX cabinet or in a separate enclosure suitable for wall mounting.

The PABX shall be able to operate on -48 Volt DC (nominal). It shall have power supply and control cards in hot-standby mode so that in case of failure of one the other takes over automatically. Alternatively, distributed power supply architecture is also acceptable.

1.3 Equipment Availability: PABX system shall have 99.99% availability. Equipment shall be capable of providing suitable alarm indication in order to determine malfunction/fault condition.

1.4 Testing & Inspection:

The offered PABX shall be type tested as per relevant standards. The bidder shall submit the previous type test reports. The FAT & SAT for PABX shall be conducted as per requirement specified in this Section.

1.5 Factory Acceptance Tests

Factory acceptance tests shall be conducted on final assemblies of all equipment to be supplied.

Equipment/Material shall not be dispatched to the Employer until required factory tests are completed satisfactorily, all variances are resolved, full test documentation has been delivered to the Employer, and the Employer has issued Material Inspection & Clearance Certificate (MICC). Successful completion of the factory tests and the Employer approval to dispatch shall in no way constitute final acceptance of the system or any portion thereof. These tests shall be carried out in the presence of the Employer's/Owner’s authorised representatives.

Factory acceptance tests shall not proceed without the prior delivery to and approval of all test documentation by the Employer.

The factory acceptance test shall demonstrate the technical characteristics of the equipment in relation to this specifications and approved drawings and documents. The factory acceptance tests shall be proposed by the Contractor in accordance with technical specifications and Contractor's (including Sub-Contractor's /supplier's) standard FAT testing program which shall be finalised during detailed during engineering. In general the FAT shall include at least: Physical verification, demonstration of technical characteristics, various operational modes, functional interfaces, alarms and diagnostics etc.

1.6 Production Testing

Production testing shall mean those tests which are to be carried out during the process of production by the Contractor to ensure the desired quality of end product to be supplied by him. The production tests to be carried out at each stage of production shall be based on the Contractor's standard quality assurance procedures. The production tests to be carried out shall be listed in the Manufacturing Quality Plan (MQP), along with information such as sampling frequency, applicable standards, acceptance criteria etc.

The production tests would normally not be witnessed by the Employer. However, the Employer reserves the right to do so or inspect the production testing records in accordance with Inspection rights specified for this contract.

1.7 Site Acceptance Tests (SAT)

The Contractor shall be responsible for carrying out site tests and inspection for all equipment supplied in this contract as required by the Employer. All equipment shall be tested on site under the conditions in which it will normally operate. The site acceptance tests shall be proposed by the Contractor in accordance with technical specifications and Contractor's(including Sub-Contractor's /supplier's) standard Site Acceptance Testing program which shall be finalised during detailed during engineering.The tests shall be exhaustive and shall demonstrate that the overall performance of the contract works satisfies every requirement specified.

C. <u>DISTANCE TO FAULT LOCATOR (Travelling Wave type):</u>

1. Distance to Fault locator, based on Traveling wave detection method, shall

a. be microprocessor based, On-line type
b. have programmable triggering thresholds
c. be suitable for breaker operating time of minimum 2 cycles
d. consist of acquisition unit at both ends of each line and one common central unit at each substation.
e. provide fault location reading directly in kilo-meter without requiring any further calculations
f. have fault location accuracy of ± 150 Meter or better with a least count of at least 50 meter for fault locator readings
g. The above accuracy should not be affected by followings:

h. Line length
   - Presence of remote end in-feed
   - Series compensation
   - Non-uniform line (having cable & overhead line both)
   - Mutual coupling
   - Transposition of line
   - Fault resistance
   - Severe CVT transients

2. The acquisition units shall be either standalone for each line or composite unit with the capability to cater to **multiple lines** emanating from the substations. Incase more than one lines are to be accommodated in one acquisition unit, then suitable coupler unit shall be provided in individual line bay C&R panels and only secondary wiring shall be brought to common acquisition unit. While offering this option, bidders are advised to take care of maximum distance between acquisition unit & line bays C&R panels, which shall be placed in different kiosks at 400/220 kV Dhalkebar S/s & its concomitant substations and in the relay room of GIS hall at 400/220 kV Dhalkebar substations. Acquisitions units can be mounted in a separate panel or in the respective line protection panels.

3. The Acquisition unit (one each at both ends) shall

a. include all required accessories (like couplers, cables, connectors etc) to connect to the secondary wiring of the Instrument transformers (in C&R panels) for detection of traveling wave
b. have built-in backlit display unit and keypad
c. have the facility to locally download the data in case of communication failure
d. have minimum 02 nos. binary input per line for line protection trip input. Binary input shall be rated for 220V DC and it shall be possible to set the de-bounce time of the binary input.
e. have minimum 4GB of storage space
f. have facility to transmit the fault record to the Central unit by dialing mode, IEC60870-5-103, IEC60870-5-104 net protocol. Scope shall include a dialup modem if required with each Acquisition unit.

The Acquisition unit shall include required GPS time synchronizing units for each substation (internal or external to Acquisition unit)

The common Central unit shall:

a. be able to cater the requirement of at least 8 Acquisition units.

b. have all necessary hardware & software for data download from Acquisition units, storage, processing, device (acquisition unit) creation and configuration, and comprehensive viewer for manual analysis of waveform. It will also have diagnostic feature to check the healthiness of connected devices & communication link.

c. consist of a desktop personal computer (including at least 17" TFT colour monitor, mouse and keyboard), colour laser jet multi-function printer, LAN switches (as required), all special cables and other required accessories. The desktop PC shall have Intel I3 (third Generation) or better processor. The hard disk capacity of PC shall not be less than 750 GB and RAM capacity shall not be less than 4 GB.

d. calculate & report the fault location based on the traveling wave data acquired from acquisition units of both end of the line. However, Central data processing unit shall have the facility to calculate the fault location even with only one end acquisition unit data of the line.

e. be able to communicate to the Master station (Control center) through IEC60870-5-104 net protocol.

f. be located at local or any remote end based on the availability of communication link.

Central data processing unit of Travelling wave fault locator shall be suitable for integration of future acquisition units (including the existing lines) of the transmission lines as per SLD

5. End to end communication link shall be provided by NEA. However Scope shall also include a dialup modem with central data processing unit. All necessary wiring from Acquisition /Central data processing up to communication gate way shall be in the scope of the contract.

6. The manufacturer whose travelling wave fault locators are offered should have supplied and commissioned travelling wave fault locators on power transmission lines of 132kV or above voltage level and the equipment shall be in operation for two years

7. The following type test report may be submitted for the fault locator acquisition unit:

a) *EMI/EMC as per relevant IEC*
b) *Insulation test as per 60255 – 5.*

ANNEXURE – V

Technical Specifications for Visual Monitoring System

Visual monitoring system for watch and ward of Substation premises:

Visual monitoring system (VMS) for effective watch and ward of substation premises covering the areas of entire switchyard, Control Room cum Administrative building, Firefighting pump house, stores and main gate, shall be provided. The contractor shall design, supply, erect, test and commission the complete system including cameras, Digital video recorder system, mounting arrangement for cameras, cables, LAN Switches, UPS and any other items/accessories required to complete the system. To provide all the necessary licenses to run the system successfully shall be in the scope of contractor.

System with Color IP Cameras for VMS surveillance would be located at various locations including indoor areas and outdoor switchyard and as per the direction of Engineer-In-Charge. The VMS data partly/completely shall be recorded (minimum for 15 days) and stored on network video recorder.

The number of cameras and their locations shall be decided in such a way that any location covered in the area can be scanned. The cameras shall be located in such a way to monitor at least:

1. The operation of each and every isolator pole of the complete yard (including future scope).
2. All the Transformer and Reactors (including future scope)
3. All the Entrance doors of Control Room Building and Fire-fighting Pump House and Switchyard Panel room.
4. All the gates of switchyard.
5. Main entrance Gate
6. All other Major Equipments (such as CB, CT, CVT, SA etc. for present and future)

   The cameras can be mounted on structures, buildings or any other suitable mounting arrangement to be provided by the contractor.

1.1 Technical requirements of major equipment of Visual Monitoring System.

1.1.1 The Video Monitoring system shall be an integrated system with IP network centric functional and management architecture aimed at providing high-speed manual/automatic operation for best performance.

1.1.2 The system should facilitate viewing of live and recorded images and controlling of all cameras by the authorized users.

1.1.3 The system shall use video signals from various types of indoor/outdoor CCD colour cameras installed at different locations, process them for viewing on workstations/monitors in the control Room and simultaneously record all the cameras after compression using **H 264/**MPEG 4 or better standard. Mouse/Joystick-Keyboard controllers shall be used for Pan, Tilt, Zoom, and other functions of desired cameras.

1.1.4 The System shall provide sufficient storage of all the camera recordings for a period of 15 days or more @ 25 FPS, at 4 CIF or better quality using necessary compression techniques for all cameras. It shall be ensured that data once recorded shall not be altered by any means. The recording resolution and frame rate for each camera shall be user programmable.

1.1.5 The surveillance VMS System shall operate on 230 V, 50 Hz single-phase power supply. System shall have back up UPS power supply meeting the power supply need of all the cameras in the stations including those which are installed at gate for a period of 2 hours. The bidder shall submit the sizing calculation for the UPS considering the total load requirement of Video Monitoring System.

1.2 System requirements:

a) System must provide built-in facility of watermarking or Digital certificate to ensure tamperproof recording.

b) All cameras may be connected through a suitable LAN which shall be able to perform in 400kV class sub-station environment without fail.

c) All camera recordings shall have Camera ID & location/area of recording as well as date/time stamp. Camera ID, Location/Area of recording & date/time shall be programmable by the system administrator with User ID & Password.

d) Facility of camera recording in real-time mode (25 FPS)/15/12.5/10 or lower FPS as well as in any desired combination must be available in the system.

e) Facility of Camera recording in HD (1280X720p), D1, 4CIF, CIF, VGA, as well as in any combination i.e. any camera can be recorded in any quality.

f) System to have facility of **100%** additional camera installation beyond the originally planned capacity.

g) In order to optimize the memory, while recording, video shall be compressed using H **264/**MPEG-4 or better standard and streamed over the IP network.

h) System shall be triplex i.e. it should provide facility of Viewing, Recording & Replay simultaneously.

i) The offered system shall have facility to export the desired portion of clipping (from a specific date/time to another specific date/time) on CD or DVD. Viewing of this recording shall be possible on standard PC using standard software like windows media player etc.

j) System shall have provision of WAN connectivity for remote monitoring.

k) The equipment should generally conform to Electromagnetic compatibility requirements for outdoor equipment in EHV switchyards. The major EMC required for Cameras and other equipment shall be as under:

1. Electrical Fast Transient (Level 4) – As per IEC 61000-4-4
2. Damped Oscillatory (1 MHz and 100 KHz) (level 3) – As per IEC 61000-4-12
3. AC Voltage Dips & Interruption/Variation (level 4) – As per IEC 61000-4-12
4. Electrostatic Discharge (Level 4) – As per IEC 61000-4-2
5. Power Frequency Magnetic Field (level 4) – As per IEC 61000-4-8
6. Ripple on DC Power Supply (level 4) – As per IEC 61000-4-17

Type test reports to establish compliance with the above requirement shall be submitted during detailed engineering.

1.2.1 VIDEO SURVEILLANCE APPLICATION SOFTWARE

a) Digital video surveillance control software should be capable to display and manage the entire surveillance system. It should be capable of supporting variety of devices such as cameras, video encoder, Servers, NAS boxes/Raid backup device etc.

b) The software should have inbuilt facility to store configuration of encoders and cameras.

c) The software should Support flexible 1/2/4/8/16/32 Windows Split screen display mode and scroll mode on the PC monitor.

d) The software should be able to control all cameras i.e. PTZ control, Iris control, auto / manual focus, and color balance of camera, Selection of presets, Video tour selection etc.

e) The software should have user access authority configurable on per device or per device group basis. The system shall provide user activity log with user ID, time stamp, action performed, etc.

f) The users should be on a hierarchical basis as assigned by the administrator. The higher priority person can take control of cameras, which are already being controlled by a lower priority user.

g) It should have recording modes viz. continuous, manual, or programmed modes on date, time and camera-wise. All modes should be disabled and enabled using scheduled configuration. It should also be possible to search and replay the recorded images on date, time and camera-wise. It should provide onscreen controls for remote operation of PTZ cameras. It should have the facility for scheduled recording. Different recording speeds (fps) and resolution for each recording mode for each camera should be possible.

h) The software for clients should also be working on a browser based system for remote users. This will allow any authorized user to display the video of any desired camera on the monitor with full PTZ and associated controls.

i) Retrieval: The VMS application should allow retrieval of data instantaneously or any date / time interval chosen through search functionality of the application software. In case data is older than 15 days and available, the retrieval should be possible. The system should also allow for backup of specific data on any drives like DVD's or any other device in a format which can be replayed through a standard PC based software. Log of any such activity should be maintained by the system.

j) VMS shall provide the full functionality reporting tool which can provide reports for user login/logoff, camera accessibility report, server health check reports etc.

1.2.2 Network video recorder

The Network Video recorder shall include at least Server (min 3.0 GHZ, 4GB RAM, 3000GB HDD(min)), RAID 5 ,with suitable configuration along with Colored TFT 22" High resolution monitor, and Internal DVD writer. Windows XP/Vista/7 Prof. or VMS compatible operating system latest version with hardware like graphic cards, licensed Anti-virus etc.

Further the digital video recorder shall conform to the following requirements:

1.	Server Spec	Intel Quad Core (or better) 3.0 Ghz (min.) , 8 MB Cache , 4 GB memory , with suitable NVIDIA graphics card,3 TB HDD , Raid 5
2.	Recording and Display Frame Rate	Real-time 25 frames per second per channel , manual select
3.	Recording Resolution	(PAL): 1280X720 , 704(H) x 586(V) It should be possible to select lower resolutions
4.	Compression Method	H.264/MPEG-4 or better and latest
5.	Video Motion Detection Capable	Standard and built-in (selectable in menu)
6.	Monitoring Options	Split screen 1, 2, 4 , 8, 16, 32 or more cameras
7.	Playback Options	Search, still image capture
8.	Alarm/Event Recording Capable	To be provided with built-in external alarm input/ output ports minimum(8 in, 2 out)
9.	Network Operation Capable	To be provided by using WAN or LAN router
10.	Remote Internet Viewing Capable	Using WAN or LAN router
11.	HDD Storage Consumption	1GB ~ per hour / channel variable based on frame speed and resolution settings, as well as compression
12.	Operation	Triplex operation (simultaneous recording, playback, network operation)
13.	Number of Video Channel	32
14.	Audio Recording Capable	32
15.	Input Voltage	230V AC or equivalent with UPS as a back up for 30 minutes.

1.2.3 VMS Camera

a) The color IP camera for substation shall have PAN, TILT and ZOOM facilities so that it can be focused to the required location from the remote station through a controller. Whereas wireless IP cameras with PTZ controls are required for installation at gates of the NEA premises as per the direction of Engineer-In-Charge

b) The IP Camera at the main gate can be fixed or PTZ based and shall be used for monitoring entry and exit

c) It should have sufficient range for viewing all the poles of isolators and other equipments with high degree of clarity.

d) The VMS camera shall be suitable for wall mounting, ceiling mounting and switchyard structure mounting.

e) It shall be possible to define at 128 selectable preset locations so that the camera gets automatically focused on selection of the location for viewing a predefined location.

f) The camera should be able to detect motion in day & night environments having light intensity of Color: 0.5 Lux; B&W:0.05 Lux

g) Housing of cameras meant for indoor use shall be of IP 42 or better rating whereas outdoor camera housing shall be of IP 66 or better rating. Housing shall be robust and not have the effect of electromagnetic induction in 400KV switchyard.

h) All camera recordings shall have Camera ID & location/area of recording as well as date/time stamp. Camera ID, Location/Area of recording & date/time shall be programmable by the system administrator with User ID & Password

i) Facility of camera recording in real-time mode (25 FPS)/15/12.5/10 or lower FPS as well as in any desired combination must be available in the system.

A. Outdoor IP Fixed Megapixel Camera Specifications (For Main Gate)

1.	Image Sensor	2-megapixel Progressive, 1/3" CMOS/CCD sensor, Minimum illumination 0.1 Lux
2.	Min Luminous	0.5LUX(Color) 0.05Lux(Black)
3.	Camera Enclosure Type	IP66 Grade
4.	Iris/Focus	Auto/Manual
5.	Video Compression	Dual Stream H.264 and MPEG 4 user selectable
6.	Support Dual-stream	primary/secondary stream, H.264/MPEG 4 optional
7.	Video Definition	Primary stream:1600x1200,1280x960,1280x720, Secondary stream:800x600,400x288,192x144
8.	Video Parameters	Brightness, hue, contrast, saturation and image quality
9.	Video Frame Rate	PAL: 1-25frames/second NTSC:1-30frames/second
10.	Video Compression BR	32Kbit/S - 6Mbit/S
11.	Video Output	One channel composite Streaming
12.	Supported Protocols	TCP, UDP, IP, HTTP, FTP, SMTP, DHCP, DNS,ARP, ICMP, POP3, NTP, IPsec, UpnP, RTP, RTCP
13.	Operating Temperature	-5 ~ +50℃
14.	Operating Humidity	10 ~ 90%

B. Outdoor IP66 PTZ HD Camera Specifications (For Switch Yards)

1.	Image sensor	1/3 type Solid State Progressive Scan CCD,WDR(High Definition)
2.	Security	Multiple user access with password protection
3.	Effective Pixels	**(PAL): Main Stream：1280x720** Sub Stream：640x360、320x280 selectable
4.	Compression	Dual Stream H.264 and MPEG 4 user selectable
5.	Signal System	50 Hz
6.	S/N (signal to noise) Ratio	Better than 50 dB
7.	Electronic Shutter	1/60 ~ 1/10,000 sec. automatic or better
8.	Scanning System	Progressive/interlace
9.	Low Light Sensitivity (lux)	Color: 0.5 Lux; B&W:0.02 Lux
10.	Lens	Minimum 10x (minimum) optical in High Definition

		(The system shall be able to zoom the images on the monitor without any distortion to the maximum level of optical zoom)
11.	Lens Size	Minimum 4.1~73.8 mm
12.	Lens Aperture	F1.6(wide)~F2.8(tele), f=4.1~41.0mm, 10X Zoom, Video Auto Focus Angle of View Horizontal : 52°(wide) , 2.8°(tele)
13.	PTZ Data Transfer Baud/Bit Rates Supported	Selectable 2400 bps / 4800 bps / 9600 bps
14.	Panning Range	Complete 360 degrees (horizontal)
15.	Pan Speed	Adjustable, 0.1 degrees / second ~ 250 degrees / second
16.	Tilting Range	Minimum 180° Tilt Rotation
17.	Tilt Speed	Adjustable, 0.1 degrees / second ~ 150 degrees / second
18.	In Built Storage	Camera should have inbuilt storage TF or SD format for recording and storing Pictures
19.	IP Class	IP66 Standard
20.	Working temperature	-0°C ~ +50°C
21.	Working Humidity	10 ~ 90%

1.2.4 PTZ-Keyboards

The features of PTZ shall include:

- Fully functional dynamic keyboard/joystick controllers
- Controls all pan, tilt, zoom, iris, preset functions
- Control up to 255 units from a single keyboard
- Many preset options and advanced tour programming
- Compatible with all connected cameras

1.	Key Application	wired keyboard control operation of PTZ functions for weatherproof dome cameras
2.	Pan / Tilt / Zoom Protocol Languages Supported	Selectable
3.	PTZ Data Transfer Baud Rates Supported	selectable 1200 bps / 2400 bps / 4800 bps / 9600 bps
4.	Additional Features	dynamic joystick for smooth camera movements, preset location option for quick access to frequently monitored areas

Chapter 2: General Technical Requirement

1.0 FOREWORD

1.1 The provisions under this chapter are intended to supplement general requirements for the materials, equipments and services covered under other chapters of tender documents and is not exclusive.

2.0 GENERAL REQUIREMENT

2.1 The contractor shall furnish catalogues, engineering data, technical information, design documents, drawings etc., fully in conformity with the technical specification during detailed engineering.

2.2 It is recognised that the Contractor may have standardised on the use of certain components, materials, processes or procedures different from those specified herein. Alternate proposals offering similar equipment based on the manufacturer's standard practice will also be considered provided such proposals meet the specified designs, standard and performance requirements and are acceptable to Employer.

2.3 Equipment furnished shall be complete in every respect with all mountings, fittings, fixtures and standard accessories normally provided with such equipment and/or needed for erection, completion and safe operation of the equipment as required by applicable codes though they may not have been specifically detailed in the Technical Specifications unless included in the list of exclusions. Materials and components not specifically stated in the specification and bid price schedule but which are necessary for commissioning and satisfactory operation of the switchyard/substation unless specifically excluded shall be deemed to be included in the scope of the specification and shall be supplied without any extra cost. All similar standard components/parts of similar standard equipment provided, shall be inter-changeable with one another.

3.0 STANDARDS

3.1 The works covered by the specification shall be designed, engineered, manufactured, built, tested and commissioned in accordance with the Acts, Rules, Laws and Regulations of Nepal/.relevant IEC standard or Acceptable International Standard.

3.2 The equipment to be furnished under this specification shall conform to latest issue with all amendments (as on the date of bid opening) of standard specified under Annexure-A of this chapter, unless specifically mentioned in the specification.

3.3 The Bidder shall note that standards mentioned in the specification are not mutually exclusive or complete in themselves, but intended to compliment each other.

3.4 The Contractor shall also note that list of standards presented in this specification is not complete. Whenever necessary the list of standards shall be considered in conjunction with specific IEC or equivalent international standard.

3.5 When the specific requirements stipulated in the specifications exceed or differ than those required by the applicable standards, the stipulation of the specification shall take precedence.

3.6 Other internationally accepted standards which ensure equivalent or better performance than that specified in the standards specified under Annexure-A / individual chapters for various equipments shall also, be accepted, however the salient points of difference shall be clearly brought out in the Additional information schedule of the bid along with English language version of such standard. The equipment conforming to standards other than specified under Annexure-A/ individual chapters for various equipments shall be subject to Employer’s approval.

4.0 SERVICES TO BE PERFORMED BY THE EQUIPMENT BEING FURNISHED

4.1 The equipment furnished under this specification shall perform all its functions and operate satisfactorily without showing undue strain, restrike etc under such over voltage conditions.

4.2 All equipments shall also perform satisfactorily under various other electrical, electromechanical and meteorological conditions of the site of installation.

4.3 All equipment shall be able to withstand all external and internal mechanical, thermal and electromechanical forces due to various factors like wind load, temperature variation, ice & snow, (wherever applicable) short circuit etc for the equipment.

4.4 The bidder shall design terminal connectors of the equipment taking into account various forces that are required to withstand.

4.5 The equipment shall also comply with the following:

a) To facilitate erection of equipment, all items to be assembled at site shall be “match marked”.

b) All piping, if any between equipment control cabinet and operating mechanisms to marshalling box of the equipment, shall bear proper identification to facilitate the connection at site.

4.6 Equipments and system shall be designed to meet the following major technical parameters as brought out hereunder.

4.6.1 System Parameter

400kV & 220kV System

S. N.	Description of parameters	400 kV System	220 kV System
1.	System operating voltage	400kV	220kV
2.	Maximum operating voltage of the system(rms)	420kV	245kV
3.	Rated frequency	50Hz	50Hz
4.	No. of phase	3	3
5.	Rated Insulation levels		
i)	Full wave impulse withstand voltage (1.2/50 micro sec.)	1425kVp	1050 kVp
ii)	Switching impulse withstand voltage (250/2500 micro sec.) dry and wet	1050kVp	-
iii)	One minute power frequency dry withstand voltage (rms)	630kV	-
iv)	One minute power frequency dry and wet withstand voltage (rms)	-	460kV
6.	Corona extinction voltage	320kV	156kV
7.	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz at **266k**V rms for 400kV system and 156kV rms for 220kV system	1000 micro- volt	1000 micro- volt
8.	Minimum creepage distance (25mm/kV)	10500 mm	6125 mm
9.	Min. clearances		
i.	Phase to phase	4000mm (for conductor- conductor configuration) 4200mm (for rod - conductor configuration)	2100 mm
ii.	Phase to earth	3500 mm	2100 mm

S. N.	Description of parameters	400 kV System	220 kV System
iii)	Sectional clearances	6500 mm	5000 mm
10.	Rated short circuit current for 1 sec. duration	40kA/50kA/ 63 kA (as applicable)	40kA/ 50kA(as applicable)
11.	System neutral earthing	Effectively earthed	Effectively earthed

132kV, 66kV, 33kV & 11kV System

SL No	Description of Parameters	132 kV System	66kV System	33 kV System	11kV System
1.	System operating voltage	132kV	66kV	33kV	11kV
2.	Maximum operating voltage of the system(rms)	145kV	72.5kV	36kV	12kV
3.	Rated frequency	50Hz	50Hz	50Hz	50Hz
4.	No. of phase	3	3	3	3
5.	Rated Insulation levels				
i)	Full wave impulse withstand voltage (1.2/50 micro sec.)	650 kVp	325 kVp	170 kVp	75 kVp
ii)	One minute power frequency dry and wet withstand voltage (rms)	275kV	140kV	70kV	28kV
6.	Corona extinction voltage	105kV	-	-	-
7.	Max. radio interference voltage for frequency between 0.5 MHz and	500 micro-volt	-	-	-
8.	Minimum creepage distance (25mm/kV)	3625 mm	1813 mm	900 mm	300 mm
9.	Min. clearances				
i.	Phase to phase	1300 mm	750 mm	320 mm	280 mm
ii.	Phase to earth	1300 mm	630 mm	320 mm	140 mm

SL No	Description of Parameters	132 kV System	66kV System	33 kV System	11kV System
iii)	Sectional clearances	4000 mm	3000 mm	3000 mm	3000 mm
10.	Rated short circuit current	31.5 kA, for 1 sec. duration	31.5 kA, for 1 sec. duration	25 kA, for 1 sec. duration	25 kA, for 1 sec. duration
11.	System neutral earthing	Effectively earthed	Effectively earthed	Effectively earthed	Effectively earthed

Note:

1. The above parameters are applicable for installations up to an altitude of 1000m above mean sea level. For altitude exceeding 1000m, necessary altitude correction factor shall be applicable.
2. The insulation and RIV levels of the equipments shall be as per values given in the respective chapter of the equipments.

4.6.2 Major technical parameters of bushings / hollow column / support insulators are given below:

400 kV and 220kV System

S.N.	Parameters	**400 kV**	**220 kV**
(a)	Max. System voltage Um(kV)	420	245
(b)	Impulse withstand voltage (dry & wet) (kVp)	± 1425	± 1050
(c)	Switching surge withstand voltage (dry & wet) (kVp)	± 1050	-
(d)	Power frequency withstand voltage (dry and wet) (kV rms)	630	460
(e)	Total creepage distance (min) (mm)	10500	6125
(f)	Insulator shall also meet requirement of IEC- 60815 for 420 kV and 245 kV systems, as applicable having alternate long & short sheds.		

132kV, 33kV & 11kV System

S.N.	Parameters	**132 kV**	**33kV**	**11kV**
(a)	Max. System voltage Um(kV)	145	36	12
(b)	Impulse withstand voltage (dry & wet) (kVp)	± 650	± 170	± 75
(c)	Power frequency withstand voltage (dry and wet) (kV rms)	275	75	28
(d)	Total creepage distance (min) (mm)	3625	900	265

4.6.3 Major Technical Parameters

The major technical parameters of the equipments are given below. For other parameters and features respective technical chapters should be referred.

(A) For 400/220/33 kV Auto Transformer

Voltage ratio (kV)	400/220/33		
Rated frequency (Hz)	50		
Max. Design Ambient Temp. (°C)	50		
Windings	HV	IV	LV
(i) System Fault level (KA)	53	40	25

(ii)	1.2/50 micro sec. impulse withstand	1300	950	250
(iii)	20/200/500 micro second switching surge withstand voltage kVp	1050	-	-
(iv)	One minute power frequency voltage kV (rms)	-	-	95
(v)	Winding connection	Star	Star	delta
(vi)	Neutral	- Solidly grounded -		
(vii)	Insulation	- Solidly grounded -		
(viii)	Vector Group	- YN a0 d11 –		

(G) For 400 KV Shunt Reactor

	Shunt Reactor	
	Rated Voltage (KV)	420 (1.0 pu)
	System fault level (KA)	40/50/63 (As applicable)
(a)	Lightning impulse 1.2/50 micro seconds withstand voltage	1300
(b)	Switching surge impulse 20/200/500 micro seconds voltage (kVp)	1050
	Insulation level of neutral	
(a)	Impulse withstand voltage (kVp)	550
(b)	Power frequency voltage (rms)	230

(B) For 420 kV Circuit Breaker and Isolator

	Rated voltage (kV, rms)	420
	Rated frequency (Hz)	50
	No. of poles	3
	Design ambient temperature (°C)	50
	Rated Insulation levels :	
1)	Full wave impulse withstand voltage (1.2/50 microsec.)	

	-	between line terminals and ground	±1425 kV peak
	-	between terminals with circuit breaker/ Isolator open	± 1425 kVp impulse on one terminal and 240 kVp power frequency voltage of opposite polarity on other terminal
2)	Switching impulse withstand voltage (250/2500 micro-second) dry and wet		
	-	between line terminals and ground	± 1050 kV peak
	-	between terminals with circuit breaker/ Isolator open	900 kVp impulse on one terminal and 345 kVp power frequency voltage of opposite polarity on other terminal
3)	One minute power frequency dry withstand voltage		
	-	between line terminals and ground	520 kV rms
	-	between terminals with circuit breaker/ Isolator open	610 kV rms
	Corona extinction voltage (kV rms) with Circuit Breaker/Isolator in all positions		320 (min)

Max. radio interference voltage (micro volts) for frequency between 0.5 MHz and 2 MHz at 266 kV rms. in all positions	1000

Minimum Creepage distance:-

i)	Phase to ground (mm)	10500
ii)	Between CB Terminals (mm)	10500
	Phase to phase spacing	6000/7000 mm (as applicable)
	Rating of Auxiliary Contacts	10 A at 220/ DC (as applicable)
	Breaking capacity of Auxiliary Contacts	2 A DC with circuit time constant of not less than 20ms.
	Phase to phase spacing (mm)	4500 or 4000 3000 or 2700
	System neutral earthing	Effectively Earthed

Auxiliary switch shall also comply with other clauses of this chapter.

(C) FOR 420 kV CT/CVT/SA

Rated voltage kV (rms)	420
Rated frequency (Hz)	50
No. of poles	1
Design ambient temperature (°C)	50

Rated insulation levels:

1) Full wave impulse withstand voltage (1.2/50 micro sec.)

-	between line terminals and ground for CT and CVT	± 1425 kV peak
-	for arrester housing	± 1425 kV peak

2) Switching impulse withstand voltage (250/2500 micro second)

-	between line terminals and ground for CT and CVT	± 1050 kV peak
-	for arrester housing	± 1050 kV peak

3) One minute power frequency dry and wet withstand voltage

-	between line terminals and ground for CT and CVT	630 kV rms. (dry)

- for arrester housing	630 kV rms (dry & wet)	
Corona extinction voltage (kV rms) for CT/CVT	320 (min)	
Max. radio interference voltage (microvolts) for frequency between 0.5 MHz and 2 MHz in all positions of the equipment.	1000 for CT/CVT 500 for SA (at 266 kV rms)	
Minimum creepage distance:-		
Phase to ground (mm)	10500	
System neutral earthing	- Effectively earthed -	
Partial discharge for :-		
- Surge arrester at 1.05 COV	- Not exceeding 50 pc. -	
- for CT/CVT	- Not exceeding 10 pc. –	

(D) For 245 kV & 145 kV Circuit Breaker and Isolator

Rated voltage kV (rms)	245	145
Rated frequency (Hz)	50	50
No. of Poles	3	3
Design ambient temperature (°C)	50	50
Rated insulation levels :		
1) Full wave impulse withstand voltage (1.2/50 micro sec.)		
- between line terminals and ground	± 1050 kVp	±650 kVp
- between terminals with circuit breaker open	± 1050 kVp	±650 kVp
- between terminals with isolator open	± 1200 kVp	±750 kVp
2) One minute power frequency dry and wet withstand voltage		
- between line terminals and ground	460 kV (rms)	275 kV (rms)
- between terminals with circuit breaker open	460 kV (rms)	275 kV (rms)

-	between terminals with Isolator open	530 kV (rms)	315kV (rms)
Max. radio interference voltage (microvolts) for frequency between 0.5 MHz and 2 MHz in all positions of the equipments.		1000 (at 156 kV rms)	500 (at 92 kV rms)
Minimum creepage distance :-			
Phase to ground (mm)		6125	3625
Between CB Terminals (mm)		6125	3625
System neutral earthing		Effectively earthed	Effectively earthed
Rating of Auxiliary Contacts		10 A at 220 DC (as applicable)	
Breaking capacity of Auxiliary Contacts		2 A DC with circuit time constant of not less than 20ms.	
Phase to phase spacing (mm)		4500 or 4000	3000 or 2700

Auxiliary Switch shall also comply with other clauses of this chapter.

(B) FOR 245 kV & 145 kV CT/CVT/SA

Rated voltage kV (rms)		245	145
Rated frequency (Hz)		50	50
No. of poles		1	1
Design ambient temperature (°C)		50	50
Rated insulation levels :			
1)	Full wave impulse withstand voltage (1.2/50 micro sec.)		
-	between line terminals and ground for CT and CVT	± 1050 kVp	±650 kVp
-	for arrester housing	± 1050 kV peak	±650 kVp
2)	One minute power frequency dry and wet withstand voltage		
-	between line terminals and ground for CT and CVT	460 kV rms	275 kV rms
-	for arrester housing	460 kV rms	275kV rms

Max. radio interference voltage (microvolts) for frequency between 0.5 MHz and 2 MHz in all positions of the equipment.	1000 for CT/CVT 500 for SA (at 156 kV rms)	500 (at 92 kV rms)
Minimum creepage distance:-		
Phase to ground (mm)	6125	3625
System neutral earthing	- Effectively earthed -	
Partial discharge for :-		
- Surge arrester at 1.05 COV	- Not exceeding 50 pc. -	
- for CT/CVT	- Not exceeding 10 pc. –	

(L) For 72.5 kV AND 36 kV EQUIPMENTS

Rated Voltage KV (rms)	72.5	36
Rated frequency (Hz)	50	50
No. of Poles	3	3
Design ambient temperature	50	3
Rated insulation levels :		
1) Full wave impulse withstand voltage (1.2/50 micro sec.)		
- between line terminals and	± 325 kVp	± 170 kVp
- between terminals with	± 375 kVp	± 180 kVp
2) One minute power frequency dry and wet withstand voltage		
- between line terminals and ground	140 kV (rms)	70 kV (rms)
- between terminals with Isolator open	160 kV (rms)	80 kV (rms)
Minimum creepage distance :-		
Phase to ground (mm)	1813	900
Rating of Auxiliary Contacts applicable) Breaking capacity of	10A at 220/110V DC (As 2 A DC with circuit	

Auxiliary Contacts	time constant of not less than 20 ms.	
Phase to phase spacing (mm)	2000	1500

Auxiliary Switch shall also comply with other clauses of this chapter.

5.0 ENGINEERING DATA AND DRAWINGS

5.1 The list of drawings/documents, which are to be submitted to the Employer, shall be discussed and finalized by the Employer at the time of award.

The Contractor shall necessarily submit all the drawings/ documents unless anything is waived.

5.2 The Contractor shall submit 4 (four) sets of drawings/ design documents /data / detailed bill of quantity and 1 (one) set of test reports for the approval of the Employer. The contractor shall also submit the softcopy of the above documents in addition to hardcopy.

5.3 Drawings

5.3.1 All drawings submitted by the Contractor shall be in sufficient detail to indicate the type, size, arrangement, material description, Bill of Materials, weight of each component, break-up for packing and shipment, dimensions, internal & the external connections, fixing arrangement required and any other information specifically requested in the specifications.

5.3.2 Drawings submitted by the Contractor shall be clearly marked with the name of the Employer, the unit designation, the specifications title, the specification number and the name of the Project. Employer/Consultant has standardized few drawings/documents of various make including type test reports which can be used for all projects having similar requirements and in such cases no project specific approval (except for list of applicable drawings alongwith type test reports) is required. However, distribution copies of standard drawings/documents shall be submitted as per provision of the contract. All titles, noting, markings and writings on the drawing shall be in English. All the dimensions should be in SI units.

5.3.3 The review of these data by the Employer will cover only general conformance of the data to the specifications and documents, interfaces with the equipment provided under the specifications, external connections and of the dimensions which might affect substation layout. This review by the Employer may not indicate a thorough review of all dimensions, quantities and details of the equipment, materials, any devices or items indicated or the accuracy of the information submitted. This review and/or approval by the Employer shall not be considered by the Contractor, as limiting any of his responsibilities and liabilities for mistakes and deviations from the requirements, specified under these specifications and documents.

5.5 All manufacturing and fabrication work in connection with the equipment prior to the approval of the drawings shall be at the Contractor's risk. The Contractor may make any changes in the design which are necessary to make the equipment conform to the provisions and intent of the Contract and such changes will again be subject to approval by the Employer. Approval of Contractor's drawing or work by the Employer shall not relieve the contractor of any of his responsibilities and liabilities under the Contract.

5.6 All engineering data submitted by the Contractor after final process including review and approval by the Employer shall form part of the Contract Document and the entire works performed under these specifications shall be performed in strict conformity, unless otherwise expressly requested by the Employer in Writing.

5.7 Approval Procedure

The scheduled dates for the submission of the drawings as well as for, any data/information to be furnished by the Employer would be discussed and finalised at the time of award. The following schedule shall be followed generally for approval and for providing final documentation.

i)	Approval/comments/ by Employer on initial submission	As per agreed schedule
ii)	Resubmission (whenever required)	Within 3 (three) weeks from date of comments
iii)	Approval or comments	Within 3 (three) weeks of receipt of resubmission.
iv)	Furnishing of distribution copies (5 hard copies per substation and one scanned copy (pdf format) for Corporate Centre)	2 weeks from the date of approval
v)	Furnishing of distribution copies of test reports	
	(a) Type test reports (one scanned softcopy in pdf format per substation plus one for corporate centre & one hardcopy per substation)	2 weeks from the date of final approval

	(b) Routine Test Reports (one copy for each substation)	-do-
vi)	Furnishing of instruction/ operation manuals (2 copies per substation and one softcopy (pdf format) for corporate centre & per substation)	As per agreed schedule
(vii)	As built drawings (two sets of hardcopy per substation & one softcopy (pdf format) for corporate centre& per substation)	On completion of entire works

NOTE :

(1) The contractor may please note that all resubmissions must incorporate all comments given in the earlier submission by the Employer or adequate justification for not incorporating the same must be submitted failing which the submission of documents is likely to be returned.

(2) All drawings should be submitted in softcopy form, however substation design drawings like SLD, GA, all layouts etc. shall also be submitted in AutoCAD Version. SLD, GA & layout drawings shall be submitted for the entire substation in case of substation extension also.

(3) The instruction Manuals shall contain full details of drawings of all equipment being supplied under this contract, their exploded diagrams with complete instructions for storage, handling, erection, commissioning, testing, operation, trouble shooting, servicing and overhauling procedures.

(4) If after the commissioning and initial operation of the substation, the instruction manuals require any modifications/ additions/changes, the same shall be incorporated and the updated final instruction manuals shall be submitted by the Contractor to the Employer.

(5) The Contractor shall furnish to the Employer catalogues of spare parts.

(6) All As-built drawings/documents shall be certified by site indicating the changes before final submission.

6.0 MATERIAL/ WORKMANSHIP

6.1 General Requirement

6.1.1 Where the specification does not contain references to workmanship, equipment, materials and components of the covered equipment, it is essential that the same must be new, of highest grade of the best quality of their kind, conforming to best engineering practice and suitable for the purpose for which they are intended.

6.1.2 Incase where the equipment, materials or components are indicated in the specification as "similar" to any special standard, the Employer shall decide upon the question of similarity. When required by the specification or when required by the Employer the Contractor shall submit, for approval, all the information concerning the materials or components to be used in manufacture. Machinery, equipment, materials and components supplied, installed or used without such approval shall run the risk of subsequent rejection, it being understood that the cost as well as the time delay associated with the rejection shall be borne by the Contractor.

6.1.3 The design of the Works shall be such that installation, future expansions, replacements and general maintenance may be undertaken with a minimum of time and expenses. Each component shall be designed to be consistent with its duty and suitable factors of safety, subject to mutual agreements. All joints and fastenings shall be devised, constructed and documented so that the component parts shall be accurately positioned and restrained to fulfill their required function. In general, screw threads shall be standard metric threads. The use of other thread forms will only be permitted when prior approval has been obtained from the Employer.

6.1.4 Whenever possible, all similar part of the Works shall be made to gauge and shall also be made interchangeable with similar parts. All spare parts shall also be interchangeable and shall be made of the same materials and workmanship as the corresponding parts of the Equipment supplied under the Specification. Where feasible, common component units shall be employed in different pieces of equipment in order to minimize spare parts stocking requirements. All equipment of the same type and rating shall be physically and electrically interchangeable.

6.1.5 All materials and equipment shall be installed in strict accordance with the manufacturer's recommendation(s). Only first-class work in accordance with the best modern practices will be accepted. Installation shall be considered as being the erection of equipment at its permanent location. This, unless otherwise specified, shall include unpacking, cleaning and lifting into position, grouting, levelling, aligning, coupling of or bolting down to previously installed equipment bases/foundations, performing the alignment check and final adjustment prior to initial operation, testing and commissioning in accordance with the manufacturer's tolerances, instructions and the Specification. All factory assembled rotating machinery shall be checked for alignment and adjustments made as necessary to re-establish the manufacturer's limits suitable guards shall be provided for the protection of personnel on all exposed rotating and / or moving machine parts and shall be designed for easy installation and removal for maintenance purposes. The spare equipment(s) shall be installed at designated locations and tested for healthiness.

6.1.6 The Contractor shall apply oil and grease of the proper specification to suit the machinery, as is necessary for the installation of the equipment. Lubricants used for installation purposes shall be drained out and the system flushed through where necessary for applying the lubricant required for operation. The Contractor shall apply all operational lubricants to the equipment installed by him.

6.2 Provisions for Exposure to Hot and Humid climate

Outdoor equipment supplied under the specification shall be suitable for service and storage under tropical conditions of high temperature, high humidity, heavy rainfall and environment favourable to the growth of fungi and mildew. The indoor equipments located in non-air conditioned areas shall also be of same type.

6.2.1 Space Heaters

6.2.1.1 The heaters shall be suitable for continuous operation at 230V as supply voltage. On-off switch and fuse shall be provided.

6.2.1.2 One or more adequately rated thermostatically connected heaters shall be supplied to prevent condensation in any compartment. The heaters shall be installed in the compartment and electrical connections shall be made sufficiently away from below the heaters to minimize deterioration of supply wire insulation. The heaters shall be suitable to maintain the compartment temperature to prevent condensation.

6.2.1.3 Suitable anti condensation heaters with the provision of thermostat shall be provided.

6.2.2 Fungi Static Varnish

Besides the space heaters, special moisture and fungus resistant varnish shall be applied on parts which may be subjected or predisposed to the formation of fungi due to the presence or deposit of nutrient substances. The varnish shall not be applied to any surface of part where the treatment will interfere with the operation or performance of the equipment. Such surfaces or parts shall be protected against the application of the varnish.

6.2.3 Ventilation opening

Wherever ventilation is provided, the compartments shall have ventilation openings with fine wire mesh of brass to prevent the entry of insects and to reduce to a minimum the entry of dirt and dust. Outdoor compartment openings shall be provided with shutter type blinds and suitable provision shall be made so as to avoid any communication of air / dust with any part in the enclosures of the Control Cabinets, Junction boxes and Marshalling Boxes, panels etc.

6.2.4 Degree of Protection

The enclosures of the Control Cabinets, Junction boxes and Marshalling Boxes, panels etc. to be installed shall provide degree of protection as detailed here under:

a) Installed out door: IP- 55

b) Installed indoor in air conditioned area: IP-31

c) Installed in covered area: IP-52

d) Installed indoor in non air conditioned area where possibility of entry of water is limited: IP-41.

e) For LT Switchgear (AC & DC distribution Boards): IP-52

The degree of protection shall be in accordance with IEC-60947 (Part-I) / IEC-60529. Type test report for degree of protection test, shall be submitted for approval.

6.3 RATING PLATES, NAME PLATES AND LABELS

6.3.1 Each main and auxiliary item of substation is to have permanently attached to it in a conspicuous position a rating plate of non-corrosive material upon which is to be engraved manufacturer's name, year of manufacture, equipment name, type or serial number together with details of the loading conditions under which the item of substation in question has been designed to operate, and such diagram plates as may be required by the Employer. The rating plate of each equipment shall be according to IEC requirement.

6.3.2 All such nameplates, instruction plates, rating plates of transformers, reactors, CB, CT, CVT, SA, Isolators, C & R panels and Communication equipments shall be provided with English inscriptions.

6.4 FIRST FILL OF CONSUMABLES, OIL AND LUBRICANTS

All the first fill of consumables such as oils, lubricants, filling compounds, touch up paints, soldering/brazing material for all copper piping of circuit breakers and essential chemicals etc. which will be required to put the equipment covered under the scope of the specifications, into successful Operation, shall be furnished by the Contractor unless specifically excluded under the exclusions in these specifications and documents.

7.0 DESIGN IMPROVEMENTS / COORDINATION

7.1 The bidder shall note that the equipment offered by him in the bid only shall be accepted for supply. However, the Employer or the Contractor may propose changes in the specification of the equipment or quality thereof and if the Employer & contractor agree upon any such changes, the specification shall be modified accordingly.

7.2 If any such agreed upon change is such that it affects the price and schedule of completion, the parties shall agree in writing as to the extent of any change in the price and/or schedule of completion before the Contractor proceeds with the change. Following such agreement, the provision thereof, shall be deemed to have been amended accordingly.

7.3 The Contractor shall be responsible for the selection and design of appropriate equipments to provide the best co-ordinated performance of the entire system. The basic design requirements are detailed out in this Specification. The design of various components, sub-assemblies and assemblies shall be so done that it facilitates easy field assembly and maintenance.

7.4 The Contractor has to coordinate designs and terminations with the agencies (if any) who are Consultants/Contractor for the Employer. The names of agencies shall be intimated to the successful bidders.

7.5 The Contractor will be called upon to attend design co-ordination meetings with the Engineer, other Contractor's and the Consultants of the Employer (if any) during the period of Contract. The Contractor shall attend such meetings at his own cost at Employer's Corporate Centre, Nepal or at mutually agreed venue as and when required and fully cooperate with such persons and agencies involved during those discussions.

8.0 QUALITY ASSURANCE PROGRAMME

8.1 To ensure that the equipment and services under the scope of this Contract whether manufactured or performed within the Contractor's Works or at his Sub-contractor's premises or at the Employer's site or at any other place of Work are in accordance with the specifications, the Contractor shall adopt suitable quality assurance programme to control such activities at all points necessary. Such programme shall be broadly outlined by the contractor and finalised after discussions before the award of contract. The detailed programme shall be submitted by the contractor after the award for reference. A quality assurance programme of the contractor shall generally cover the following:

(a) His organisation structure for the management and implementation of the proposed quality assurance programme:

(b) Documentation control system;

(c) Qualification data for bidder's key personnel;

(d) The procedure for purchases of materials, parts components and selection of sub-Contractor's services including vendor analysis, source inspection, incoming raw material inspection, verification of material purchases etc.

(e) System for shop manufacturing and site erection controls including process controls and fabrication and assembly control;

(f) Control of non-conforming items and system for corrective actions;

(g) Inspection and test procedure both for manufacture and field activities.

(h) Control of calibration and testing of measuring instruments and field activities;

(i) System for indication and appraisal of inspection status;

(j) System for quality audits;

(k) System for authorising release of manufactured product to the Purcahser.

(l) System for maintenance of records;

(m) System for handling storage and delivery; and

(n) A quality plan detailing out the specific quality control measures and procedures adopted for controlling the quality characteristics relevant to each item of equipment furnished and/or services rendered.

The Employer or his duly authorised representative reserves the right to carry out quality audit and quality surveillance of the system and procedure of the Contractor/his vendor's quality management and control activities.

8.2 Quality Assurance Documents

The contractor would be required to submit all the Quality Assurance Documents as stipulated in the Quality Plan at the time of Employer's inspection of equipment/material

9.0 TYPE TESTING, INSPECTION, TESTING & INSPECTION CERTIFICATE

9.1 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 chapters.

9.2 The reports for all type tests as per technical specification shall be furnished by the Contractor alongwith equipment/material drawings. 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 Utility or representative of accredited test lab.

The test reports submitted shall be of the tests conducted within last 10 (ten) years prior to the originally Scheduled date of bid opening. In case the test reports are of the test conducted earlier than 10 (ten) years prior to the originally Scheduled date of bid opening, the contractor shall repeat these test(s) at no extra cost to the Employer.

However, in case of 400 kV GIS Switchgears (Circuit Breaker, Disconnectors, Grounding Switches, Instrument Transformers, SF6/Air & Oil Bushing etc;) type test shall be carried out as per IEC in **Short-Circuit Testing Liaison (STL)** – Accredited Laboratory in line with Chapter-3 of Technical Specification.

If the manufacturer had not successfully carried out complete type test as per IEC in **Short-Circuit Testing Liaison (STL)** - Accredited Laboratory as on the originally scheduled date of bid opening, bidder have to submit undertaking letter along with bid to carry out the mentioned test in Short-Circuit Testing Liaison (STL) - Accredited Laboratory from offered Manufacturer without any extra cost to Employer.

The validity of type test reports of GIS shall be within last 10 (ten) years prior to the originally Scheduled date of bid opening. In case the test reports are of the test conducted earlier than 10 (ten) years prior to the originally Scheduled date of bid opening, the contractor shall repeat these test(s) at no extra cost to the Employer.

Further, in case of instrument transformers, the following type tests should have been conducted within 5 (five) years prior to the date of bid opening.

i) Lightning Impulse Test.

ii) Switching Impulse Test.

iii) Chopped Impulse Test (For CVT).

In case the test reports for these tests (for instrument transformers) as mentioned above are conducted earlier than 5 (five) years prior to the date of bid opening, the contractor shall repeat these test(s) at no extra cost to the Employer.

Further, in the event of any discrepancy in the test reports i.e. any test report not acceptable due to any design/manufacturing changes (including substitution of components) 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 implication to the Employer.

The Contractor shall intimate the Employer the detailed program about the tests atleast two (2) weeks in advance in case of domestic supplies & six (6) weeks in advance in case of foreign supplies.

Further, in case type tests are required to be conducted/repeated and the deputation of Inspector/Employer's representative is required, then all the expenses shall be borne by the contractor.

9.3 The Employer, his duly authorized representative and/or outside inspection agency acting on behalf of the Employer shall have at all reasonable times free access to the Contractor’s/sub-vendors premises or Works and shall have the power at all reasonable times to inspect and examine the materials and workmanship of the Works during its manufacture or erection if part of the Works is being manufactured or assembled at other premises or works, the Contractor shall obtain for the Engineer and for his duly authorised representative permission to inspect as if the works were manufactured or assembled on the Contractor’s own premises or works. Inspection may be made at any stage of manufacture, despatch or at site at the option of the Employer and the equipment if found unsatisfactory due to bad workmanship or quality, material is liable to be rejected.

9.4 The Contractor shall give the Employer /Inspector fifteen (15) days written notice for on-shore and six (6) weeks notice for off-shore material being ready for joint testing including contractor and ***Employer.*** Such tests shall be to the

Contractor's account except for the expenses of the Inspector. The Employer /inspector, unless witnessing of the tests is virtually waived, will attend such tests within fifteen (15) days of the date of which the equipment is notified as being ready for test/inspection, failing which the Contractor may proceed alone with the test which shall be deemed to have been made in the Inspector's presence and he shall forthwith forward to the Inspector duly certified copies of tests in triplicate.

9.5 The Employer or Inspector shall, within fifteen (15) days from the date of inspection as defined herein give notice in writing to the Contractor, of any objection to any drawings and all or any equipment and workmanship which in his opinion is not in accordance with the Contract. The Contractor shall give due consideration to such objections and shall either make the modifications that may be necessary to meet the said objections or shall confirm in writing to the Employer /Inspector giving reasons therein, that no modifications are necessary to comply with the Contract.

9.6 When the factory tests have been completed at the Contractor's or Sub-Contractor's works, the Employer/inspector shall issue a certificate to this effect within fifteen (15) days after completion of tests but if the tests are not witnessed by the Employer /Inspector, the certificate shall be issued within fifteen (15) days of receipt of the Contractor's Test certificate by the Engineer/Inspector. Failure of the Employer /Inspector to issue such a certificate shall not prevent the Contractor from proceeding with the Works. The completion of these tests or the issue of the certificate shall not bind the Employer to accept the equipment should, it, on further tests after erection, be found not to comply with the Contract. The equipment shall be dispatched to site only after approval of test reports and issuance of CIP by the Employer.

9.7 In all cases where the Contract provides for tests whether at the premises or at the works of the Contractor or of any Sub-Contractor, the Contractor except where otherwise specified shall provide free of charge such items as labour, materials, electricity, fuel, water, stores, apparatus and instruments as may be reasonably demanded by the Employer /Inspector or his authorised representative to carry out effectively such tests of the equipment in accordance with the Contract and shall give facilities to the Employer /Inspector or to his authorised representative to accomplish testing.

9.8 The inspection by Employer and issue of Inspection Certificate thereon shall in no way limit the liabilities and responsibilities of the Contractor in respect of the agreed quality assurance programme forming a part of the Contract.

9.9 The Employer will have the right of having at his own expenses any other test(s) of reasonable nature carried out at Contractor's premises or at site or in any other place in addition of aforesaid type and routine tests, to satisfy that the material comply with the specification.

9.10 The Employer reserves the right for getting any field tests not specified in respective chapters of the technical specification conducted on the completely assembled equipment at site. The testing equipments for these tests shall be provided by the Employer.

10.0 TESTS

10.1 Pre-commissioning Tests

On completion of erection of the equipment and before charging, each item of the equipment shall be thoroughly cleaned and then inspected jointly by the Employer and the Contractor for correctness and completeness of installation and acceptability for charging, leading to initial pre-commissioning tests at Site. The list of pre-commissioning tests to be performed are given in respective chapters and shall be included in the Contractor's quality assurance programme.

10.2 Commissioning Tests

10.2.1 The available instrumentation and control equipment will to be used during such tests and the Employer will calibrate, all such measuring equipment and devices as far as practicable.

10.2.2 Any special equipment, tools and tackles required for the successful completion of the Commissioning Tests shall be provided by the Contractor, free of cost.

10.2.3 The specific tests requirement on equipment have been brought out in the respective chapters of the technical specification.

10.3 The Contractor shall be responsible for obtaining statutory clearances from the concerned authorities for commissioning the equipment and the switchyard. However necessary fee shall be reimbursed on production of requisite documents.

11.0 PACKAGING & PROTECTION

11.1 All the equipments shall be suitably protected, coated, covered or boxed and crated to prevent damage or deterioration during transit, handling and storage at Site till the time of erection. On request of the Employer, the Contractor shall also submit packing details/associated drawing for any equipment/material under his scope of supply, to facilitate the Employer to repack any equipment/material at a later date, in case the need arises. While packing all the materials, the limitation from the point of view of availability of Railway wagon sizes should be taken into account. The Contractor shall be responsible for any loss or damage during transportation, handling and storage due to improper packing. Any demurrage, wharfage and other such charges claimed by the transporters, railways etc. shall be to the account of the Contractor. Employer takes no responsibility of the availability of the wagons.

11.2 All coated surfaces shall be protected against abrasion, impact, discolouration and any other damages. All exposed threaded portions shall be suitably protected with either a metallic or a non-metallic protecting device. All ends of all valves and pipings and conduit equipment connections shall be properly sealed with suitable devices to protect them from damage.

12.0 FINISHING OF METAL SURFACES

12.1 All metal surfaces shall be subjected to treatment for anti-corrosion protection. All ferrous surfaces for external use unless otherwise stated elsewhere in the specification or specifically agreed, shall be hot-dip galvanized after fabrication. High tensile steel nuts & bolts and spring washers shall be electro galvanized to service condition 4. All steel conductors including those used for earthing/grounding (above ground level) shall also be galvanized according to Equivalent International Standards.

12.2 Hot Dip Galvanising

12.2.1 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. 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.

12.2.2 The galvanized surfaces shall consist of a continuous and uniform thick coating of zinc, firmly adhering to the surface of steel. The finished surface shall be clean and smooth and shall be free from defects like discoloured patches, bare spots, unevenness of coating, spelter which is loosely attached to the steel globules, spiky deposits, blistered surface, flaking or peeling off, etc. The presence of any of these defects noticed on visual or microscopic inspection shall render the material liable to rejection.

12.2.3 After galvanizing. no drilling or welding shall be performed on the galvanized parts of the equipment excepting that nuts may be threaded after galvanizing. Sodium dichromate treatment shall be provided to avoid formation of white rust after hot dip galvanization.

12.2.4 The galvanized steel shall be subjected to six one minute dips in copper sulphate solution as per IEC.

12.2.5 Sharp edges with radii less than 2.5 mm shall be able to withstand four immersions of the Standard Preece test. All other coatings shall withstand six immersions. The following galvanizing tests should essentially be performed as per relevant International Standards.

- Coating thickness
- Uniformity of zinc
- Adhesion test
- Mass of zinc coating

12.2.6 Galvanised material must be transported properly to ensure that galvanised surfaces are not damaged during transit. Application of zinc rich paint at site shall not be allowed.

12.3 PAINTING

12.3.1 All sheet steel work shall be degreased, pickled, phosphated in accordance with the relevant international standard. All surfaces, which will not be easily accessible after shop assembly, shall beforehand be treated and protected for the life of the equipment. The surfaces, which are to be finished painted after installation or require corrosion protection until installation, shall be shop painted with at least two coats of primer. Oil, grease, dirt and swaf shall be thoroughly removed by emulsion cleaning. Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying.

12.3.2 After phosphating, thorough rinsing shall be carried out with clean water followed by final rinsing with dilute dichromate solution and oven drying. The phosphate coating shall be sealed with application of two coats of ready mixed, stoving type

zinc chromate primer. The first coat may be "flash dried" while the second coat shall be stoved.

12.3.3 After application of the primer, two coats of finishing synthetic enamel paint shall be applied, each coat followed by stoving. The second finishing coat shall be applied after inspection of first coat of painting.

12.3.4 The exterior and interior colour of the paint in case of new substations shall preferably be RAL 7032 for all equipment, marshalling boxes, junction boxes, control cabinets, panels etc. unless specifically mentioned under respective chapters of the equipments. Glossy white colour inside the equipments /boards /panels/junction boxes is also acceptable. The exterior colour for panels shall be matching with the existing panels in case of extension of a substation. Each coat of primer and finishing paint shall be of slightly different shade to enable inspection of the painting. A small quantity of finishing paint shall be supplied for minor touching up required at site after installation of the equipments.

12.3.5 In case the Bidder proposes to follow his own standard surface finish and protection procedures or any other established painting procedures, like electrostatic painting etc., the procedure shall be submitted alongwith the Bids for Employer's review & approval.

12.3.6 The colour scheme as given below shall be followed for Fire Protection and Air Conditioning systems

S.No.	PIPE LINE	Base colour	Band colour

Fire Protection System			
1	Hydrant and Emulsifier system pipeline	FIRE RED	-
2	Emulsifier system detection line – water	FIRE RED	Sea Green
3	Emulsifier system detection line – Air	FIRE RED	Sky Blue
4	Pylon support pipes	FIRE RED	
Air Conditioning System			
5	Refrigerant gas pipeline – at compressor suction	Canary Yellow	-
6	Refrigerant gas pipeline – at compressor discharge	Canary Yellow	Red
7	Refrigerant liquid pipeline	Dark Admiralty Green	-
8	Chilled water pipeline	Sea Green	-
9	Condenser water pipeline	Sea Green	Dark Blue

The direction of flow shall be marked by → (arrow) in black colour.

Base Colour Direction of flow Band Colour

12.3.7 For aluminium casted surfaces, the surface shall be with smooth finish. Further, in case of aluminium enclosures the surface shall be coated with powder (coating thickness of 60 microns) after surface preparation for painting.

13.0 HANDLING, STORING AND INSTALLATION

13.1 In accordance with the specific installation instructions as shown on manufacturer's drawings or as directed by the Employer or his representative, the Contractor shall unload, store, erect, install, wire, test and place into commercial use all the equipment included in the contract. Equipment shall be installed in a neat, workmanlike manner so that it is level, plumb, square and properly aligned and oriented. Commercial use of switchyard equipment means completion of all site tests specified and energisation at rated voltage.

13.2 Contractor may engage manufacturer's Engineers to supervise the unloading, transportation to site, storing, testing and commissioning of the various equipment being procured by them separately. Contractor shall unload, transport, store, erect, test and commission the equipment as per instructions of the manufacturer's supervisory Engineer(s) and shall extend full cooperation to them.

13.3 The contractor shall have to ensure that the hard and flat indoor and outdoor storage areas are in place prior to commencement of delivery of material at site. Contractor shall also ensure availability of proper unloading and material handling equipment like cranes etc. and polyester/nylon ropes of suitable capacity to avoid damage during unloading and handling of material at site. All indoor equipments shall be stored indoors. Outdoor equipment may be stored outdoors but on a hard and flat raised area properly covered with waterproof and dustproof covers to protect them from water seepage and moisture ingress. However, all associated control panels, marshalling boxes operating boxes etc. of outdoor equipments are to be stored indoors only.

Storage of equipment on top of another one is not permitted if the wooden packing is used. Material opened for joint inspection shall be repacked properly as per manufacturer's recommendations.

During storage of material regular periodic monitoring of important parameters like oil level / leakage, SF6 / Nitrogen pressure etc. shall be ensured by the contractor.

13.4 In case of any doubt/misunderstanding as to the correct interpretation of manufacturer's drawings or instructions, necessary clarifications shall be obtained from the Employer. Contractor shall be held responsible for any damage to the equipment consequent to not following manufacturer's drawings/instructions correctly.

13.5 Where assemblies are supplied in more than one section, Contractor shall make all necessary mechanical and electrical connections between sections including the connection between buses. Contractor shall also do necessary adjustments/alignments necessary for proper operation of circuit breakers, isolators and their operating mechanisms. All components shall be protected against damage during unloading, transportation, storage, installation, testing and commissioning. Any equipment damaged due to negligence or carelessness or otherwise shall be replaced by the Contractor at his own expense.

13.6 Contractor shall be responsible for examining all the shipment and notify the Employer immediately of any damage, shortage, discrepancy etc. for the purpose of Employer's information only. The Contractor shall submit to the Employer every week a report detailing all the receipts during the weeks. However, the Contractor shall be solely responsible for any shortages or damages in transit, handling and/or in storage and erection of the equipment at Site. Any demurrage, wharfage and other such charges claimed by the transporters, railways etc. shall be to the account of the Contractor.

13.7 The Contractor shall be fully responsible for the equipment/material until the same is handed over to the Employer in an operating condition after commissioning. Contractor shall be responsible for the maintenance of the equipment/material while in storage as well as after erection until taken over by Employer, as well as protection of the same against theft, element of nature, corrosion, damages etc.

13.8 Where material / equipment is unloaded by Employer before the Contractor arrives at site or even when he is at site, Employer by right can hand over the same to Contractor and there upon it will be the responsibility of Contractor to store the material in an orderly and proper manner.

13.9 The Contractor shall be responsible for making suitable indoor storage facilities, to store all equipment which requires indoor storage.

13.10 The words 'erection' and 'installation' used in the specification are synonymous.

13.11 Exposed live parts shall be placed high enough above ground to meet the requirements of electrical and other statutory safety codes.

13.12 The design and workmanship shall be in accordance with the best engineering practices to ensure satisfactory performance throughout the service life. If at any stage during the execution of the Contract, it is observed that the erected equipment(s) do not meet the above minimum clearances as given in clause 4.7.1 the Contractor shall immediately proceed to correct the discrepancy at his risks and cost.

13.13 Equipment Bases

A cast iron or welded steel base plate shall be provided for all rotating equipment which is to be installed on a concrete base unless otherwise agreed to by the Employer. Each base plate shall support the unit and its drive assembly, shall be of a neat design with pads for anchoring the units, shall have a raised lip all around, and shall have threaded drain connections.

14.0 TOOLS AND TACKLES

The Contractor shall supply with the equipment one complete set of all special tools and tackles for the erection, assembly, dis-assembly and maintenance of the equipment. However, these tools and tackles shall be separately, packed and brought on to Site.

15.0 AUXILIARY SUPPLY

15.1 The sub-station auxiliary supply is normally met through a system indicated under chapter "Electrical & Mechanical Auxiliaries" having the following parameters. The auxiliary power for station supply, including the equipment drive, cooling system of any equipment, air-conditioning, lighting etc shall be designed for the specified Parameters as under. The DC supply for the instrumentation and PLCC system shall also conform the parameters as indicated in the following.

Normal Voltage	Variation in Voltage	Frequency in HZ	Phase/Wire	Neutral connection

400V	± 5	50 ± 2.5%	3/4 Wire	Solidly Earthed.
230V	± 5	50 ± 2.5%	1/2 Wire	Solidly Earthed.
220V	190V to 240V	DC	-	Isolated 2 wire System
110V	95V to 120V	DC	-	Isolated 2 wire System
48V	_	DC	_	2 wire system (+) earthed

Combined variation of voltage and frequency shall be limited to ± 10%.

16.0 SUPPORT STRUCTURE

16.1 The equipment support structures shall be suitable for equipment connections at the first level i.e 14.0 meter, 8.0 meter and 5.9 meter from plinth level for 420 kV and 245 kV substations respectively. All equipment support structures shall be supplied alongwith brackets, angles, stools etc. for attaching the operating mechanism, control cabinets & marshalling box (wherever applicable) etc..

16.2 Support structure shall meet the following mandatory requirements:

16.2.1 The minimum vertical distance from the bottom of the lowest porcelain part of the bushing, porcelain enclosures or supporting insulators to the bottom of the equipment base, where it rests on the foundation pad shall be 2.55 metres.

17.0 CLAMPS AND CONNECTORS INCLUDING TERMINAL CONNECTORS

17.1 All power clamps and connectors shall conform to ANSI/NEMA CC1/ Equivalent International standard and shall be made of materials listed below:

	For connecting, ACSR conductors	Aluminum alloy casting conforming to BS:1490/ Equivalent International Standard
	For connecting equipment terminals made of copper with ACSR conductors	Bimetallic connectors made from aluminum alloy casting conforming to BS:1490/ Equivalent International Standard with 2mm thick bimetallic liner.
	For connecting GI	Galvanized mild shield wire
	i) Bolts nuts and plain washers	Electrogalvanised for sizes Plain, washers below M12, for there hot dip galvanised.
	ii) Spring washers	Electrogalvanized mild steel

17.2 Necessary clamps and connectors shall be supplied for all equipment and connections. The requirement regarding external corona and RIV as specified for any equipment shall include its terminal fittings. If corona rings are required to meet these requirements they shall be considered as part of that equipment and included in the scope of work.

17.3 Where copper to aluminum connections are required, bi-metallic clamps shall be used, which shall be properly designed to ensure that any deterioration of the connection is kept to a minimum and restricted to parts which are not current carrying or subjected to stress.

17.4 Low voltage connectors, grounding connectors and accessories for grounding all equipment as specified in each particular case, are also included in the scope of Work.

17.5 No current carrying part of any clamp shall be less than 10 mm thick. All ferrous parts shall be hot dip galvanised. Copper alloy liner of minimum 2 mm thickness shall be cast integral with aluminum body or 2 mm thick bi-metallic strips shall be provided for Bi-metallic clamps.

17.6 All casting shall be free from blow holes, surface blisters, cracks and cavities. All sharp edges and corners shall be blurred and rounded off.

17.7 Flexible connectors, braids or laminated straps made for the terminal clamps for bus posts shall be suitable for both expansion or through (fixed/sliding) type connection of 4" IPS AL. tube as required. In both the cases the clamp height (top of the mounting pad to centre line of the tube) should be same.

17.8 Clamp shall be designed to carry the same current as the conductor and the temperature rise shall be equal or less than that of the conductor at the specified ambient temperature. The rated current for which the clamp/connector is designed with respect to the specified reference ambient temperature, shall also be indelibly marked on each component of the clamp/connector, except on the hardware.

17.9 All current carrying parts shall be designed and manufactured to have minimum contact resistance.

17.10 Clamps and connectors shall be designed to be corona controlled.

17.11 Tests

17.11.1 Clamps and connectors should be type tested as per NEMA CC1/ Equivalent International Standard and shall also be subjected to routine tests as per NEMA CC1/ Equivalent International Standard. Following type test reports shall be submitted for approval as per clause 9.2 above except for sl. no.(ii) & (iii) for which type test once conducted shall be applicable (i.e. the requirement of test conducted within last ten years shall not be applicable).

i) Temperature rise test (maximum temperature rise allowed is 35°C over 50°C ambient)

ii) Short time current test

iii) Corona (dry) and RIV (dry) test (for 220 KV and above voltage level clamps)

iv) Resistance test and tensile test

18.0 CONTROL CABINETS, JUNCTION BOXES, TERMINAL BOXES & MARSHALLING BOXES FOR OUTDOOR EQUIPMENT

18.1 All types of boxes, cabinets etc. shall generally conform to & be tested in accordance with IEC-60439, as applicable, and the clauses given below:

18.2 Control cabinets, junction boxes, Marshalling boxes & terminal boxes shall be made of sheet steel or aluminum enclosure and shall be dust, water and vermin proof. Sheet steel used shall be atleast 2.0 mm thick cold rolled or 2.5 mm hot rolled or alternately 1.6 mm thick stainless steel can also be used. The box shall be properly braced to prevent wobbling. There shall be sufficient reinforcement to provide level surfaces, resistance to vibrations and rigidity during transportation and installation. In case of aluminum enclosed box the thickness of aluminum shall be such that it provides adequate rigidity and long life as comparable with sheet steel of specified thickness.

18.3 A canopy and sealing arrangements for operating rods shall be provided in marshalling boxes / Control cabinets to prevent ingress of rain water.

18.4 Cabinet/boxes shall be provided with double hinged doors with padlocking arrangements. The distance between two hinges shall be adequate to ensure uniform sealing pressure against atmosphere. The quality of the gasket shall be such that it does not get damaged/cracked during the operation of the equipment.

18.5 All doors, removable covers and plates shall be gasketed all around with suitably profiled EPDM/Neoprene gaskets. The gasket shall be tested in accordance with approved quality plan, BS:4255/ Equivalent International Standard. Ventilating Louvers, if provided, shall have screen and filters. The screen shall be fine wire mesh made of brass.

18.6 All boxes/cabinets shall be designed for the entry of cables from bottom by means of weather proof and dust-proof connections. Boxes and cabinets shall be designed with generous clearances to avoid interference between the wiring entering from below and any terminal blocks or accessories mounted within the box or cabinet. Suitable cable gland plate above the base of the marshalling kiosk/box shall be provided for this purpose along with the proper blanking plates. Necessary number of cable glands shall be supplied and fitted on this gland plate. Gland plate shall have provision for some future glands to be provided later, if required. The Nickel plated glands shall be dust proof, screw on & double compression type and made of brass. The gland shall have provision for securing armour of the cable separately and shall be provided with earthing tag. The glands shall conform to BS:6121.

18.7 A 230V, single phase, 50 Hz, 15 amp AC plug and socket shall be provided in the cabinet with ON-OFF switch for connection of hand lamps. Plug and socket shall be of industrial grade.

18.8 For illumination, a fluorescent tube or CFL of approximately 9 to 15 watts shall be provided. The switching of the fittings shall be controlled by the door switch. .

For junction boxes of smaller sizes such as lighting junction box, manual operated earth switch mechanism box etc., plug socket, heater and illumination is not required to be provided.

18.9 All control switches shall be of MCB/rotary switch type and Toggle/piano switches shall not be accepted.

18.10 Positive earthing of the cabinet shall be ensured by providing two separate earthing pads. The earth wire shall be terminated on to the earthing pad and secured by the use of self etching washer. Earthing of hinged door shall be done by using a separate earth wire.

18.11 The bay marshalling kiosks shall be provided with danger plate and a diagram showing the numbering/connection/feruling by pasting the same on the inside of the door.

18.12 a) The following routine tests alongwith the routine tests as per IEC 60529/ Equivalent International Standard shall also be conducted:

i) Check for wiring

ii) Visual and dimension check

b) The enclosure of bay marshalling kiosk, junction box, terminal box shall conform to IP-55 as per IEC 60529/ Equivalent International Standard including application of, 2.0 KV rms for 1 (one) minute, insulation resistance and functional test after IP-55 test.

19.0 TERMINAL BLOCKS AND WIRING

19.1 Control and instrument leads from the switchboards or from other equipment will be brought to terminal boxes or control cabinets in conduits. All interphase and external connections to equipment or to control cubicles will be made through terminal blocks.

19.2 Terminal blocks shall be 650V grade and have continuous rating to carry the maximum expected current on the terminals and non breakable type. These shall be of moulded piece, complete with insulated barriers, stud type terminals, washers, nuts and lock nuts. Screw clamp, overall insulated, insertion type, rail mounted terminals can be used in place of stud type terminals. But preferably the terminal blocks shall be non-disconnecting stud type of Elmex or Phoenix or Wago or equivalent make.

19.3 Terminal blocks for current transformer and voltage transformer secondary leads shall be provided with test links and isolating facilities. The current transformer secondary leads shall also be provided with short circuiting and earthing facilities.

19.4 The terminal shall be such that maximum contact area is achieved when a cable is terminated. The terminal shall have a locking characteristic to prevent cable from escaping from the terminal clamp unless it is done intentionally.

19.5 The conducting part in contact with cable shall preferably be tinned or silver plated however Nickel plated copper or zinc plated steel shall also be acceptable.

19.6 The terminal blocks shall be of extensible design.

19.7 The terminal blocks shall have locking arrangement to prevent its escape from the mounting rails.

19.8 The terminal blocks shall be fully enclosed with removable covers of transparent, non-deteriorating type plastic material. Insulating barriers shall be provided between the terminal blocks. These barriers shall not hinder the operator from carrying out the wiring without removing the barriers.

19.9 Unless otherwise specified terminal blocks shall be suitable for connecting the following conductors on each side.

a)	All circuits except CT/PT circuits	Minimum of two of 2.5 sq mm copper flexible.
b)	All CT/PT circuits	Minimum of 4 nos. of 2.5 sq mm copper flexible.

19.10 The arrangements shall be in such a manner so that it is possible to safely connect or disconnect terminals on live circuits and replace fuse links when the cabinet is live.

19.11 Atleast 20 % spare terminals shall be provided on each panel/cubicle/box and these spare terminals shall be uniformly distributed on all terminals rows.

19.12 There shall be a minimum clearance of 250 mm between the First/bottom row of terminal block and the associated cable gland plate for outdoor ground mounted marshalling box and the clearance between two rows of terminal blocks shall be a minimum of 150 mm.

19.13 The Contractor shall furnish all wire, conduits and terminals for the necessary interphase electrical connections (where applicable) as well as between phases and common terminal boxes or control cabinets.

19.14 All input and output terminals of each control cubicle shall be tested for surge withstand capability in accordance with the relevant IEC Publications, in both longitudinal and transverse modes. The Contractor shall also provide all necessary filtering, surge protection, interface relays and any other measures necessary to achieve an impulse withstand level at the cable interfaces of the equipment.

21.0 LAMPS & SOCKETS

21.1 Sockets

All sockets (convenience outlets) shall be suitable to accept both 5 Amp & 15 Amp pin round plug as per Nepalese Standard. They shall be switched sockets with shutters.

21.2 Hand Lamp:

A 230 Volts, single Phase, 50 Hz AC plug point shall be provided in the interior of each cubicle with ON-OFF Switch for connection of hand lamps.

20.3 Switches and Fuses:

20.3.1 Each panel shall be provided with necessary arrangements for receiving, distributing, isolating and fusing of DC and AC supplies for various control, signalling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with miniature circuit breaker **/** switchfuse units. Selection of the main and Sub-circuit fuse ratings shall be such as to ensure selective clearance of sub-circuit faults. Potential circuits for relaying and metering shall be protected by HRC fuses (MCB's shall also accepted for protecting the relaying and metering circuits instead of HRC Fuse).

20.3.2 All fuses shall be of HRC cartridge type conforming to relevant International Standard mounted on plug-in type fuse bases. Miniature circuit breakers with thermal protection and alarm contacts will also be accepted. All accessible live connection to fuse bases shall be adequately shrouded. Fuses shall have operation indicators for indicating blown fuse condition. Fuse carrier base shall have imprints of the fuse rating and voltage.

21.0 Bushings, Hollow Column Insulators, Support Insulators:

21.1 Bushings shall be manufactured and tested in accordance with IEC-60137 while hollow column insulators shall be manufactured and tested in accordance with IEC-62155.The support insulators shall be manufactured and tested as per IEC-60168 and IEC-60273. The insulators shall also conform to IEC-60815 as applicable.

The bidder may also offer composite hollow insulators, conforming to IEC-61462.

21.2 Support insulators, bushings and hollow column insulators shall be manufactured from high quality porcelain. Porcelain used shall be homogeneous, free from laminations, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified tough and impervious to moisture.

21.3 Glazing of the porcelain shall be uniform brown in colour, free from blisters, burrs and similar other defects.

21.4 Support insulators/bushings/hollow column insulators shall be designed to have ample insulation, mechanical strength and rigidity for the conditions under which they will be used.

21.5 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 insulators/bushings when operating at the normal rated voltage.

21.6 Bushing porcelain shall be robust and capable of withstanding the internal pressures likely to occur in service. The design and location of clamps and the shape and the strength of the porcelain flange securing the bushing to the tank shall be such that there is no risk of fracture. All portions of the assembled porcelain enclosures and supports other than gaskets, which may in any way be exposed to the atmosphere shall be composed of completely non hygroscopic material such as metal or glazed porcelain.

21.7 All iron parts shall be hot dip galvanised and all joints shall be air tight. Surface of joints shall be trued up porcelain parts by grinding and metal parts by machining. Insulator/bushing design shall be such as to ensure a uniform compressive pressure on the joints.

21.8 Tests

In bushing, hollow column insulators and support insulators shall conform to type tests and shall be subjected to routine tests in accordance with relevant international standard.

22.0 MOTORS

Motors shall be "Squirrel Cage" three phase induction motors of sufficient size capable of satisfactory operation for the application and duty as required for the driven equipment and shall be subjected to routine tests as per applicable standards. The motors shall be of approved make.

22.1 Enclosures

a) Motors to be installed outdoor without enclosure shall have hose proof enclosure equivalent to IP-55 as per IEC 60529/ Equivalent International Standard. For motors to be installed indoor i.e. inside a box, the motor enclosure, shall be dust proof equivalent to IP-44 as per relevant International Standard.

b) Two independent earthing points shall be provided on opposite sides of the motor for bolted connection of earthing conductor.

c) Motors shall have drain plugs so located that they will drain water resulting from condensation or other causes from all pockets in the motor casing.

d) Motors weighing more than 25 Kg. shall be provided with eyebolts, lugs or other means to facilitate lifting.

22.2 Operational Features

a) Continuous motor rating (name plate rating) shall be at least ten (10) percent above the maximum load demand of the driven equipment at design duty point and the motor shall not be over loaded at any operating point of driven equipment that will rise in service.

b) Motor shall be capable at giving rated output without reduction in the expected life span when operated continuously in the system having the particulars as given in Clause 15.0 of this Chapter.

22.3 Starting Requirements:

a) All induction motors shall be suitable for full voltage direct-on-line starting. These shall be capable of starting and accelerating to the rated speed alongwith the driven equipment without exceeding the acceptable winding temperature even when the supply voltage drops down to 80% of the rated voltage.

b) Motors shall be capable of withstanding the electrodynamic stresses and heating imposed if it is started at a voltage of 110% of the rated value.

c) The locked rotor current shall not exceed six (6) times the rated full load current for all motors, subject to tolerance as given in relevant International Standard.

d) Motors when started with the driven equipment imposing full starting torque under the supply voltage conditions specified under Clause 15.0 shall be capable of withstanding atleast two successive starts from cold condition at room temperature and one start from hot condition without injurious heating of winding. The motors shall also be suitable for three equally spread starts per hour under the above referred supply condition.

e) The locked rotor withstand time under hot condition at 110% of rated voltage shall be more than starting time with the driven equipment of minimum permissible voltage by at least two seconds or 15% of the accelerating time whichever is greater. In case it is not possible to meet the above requirement, the Bidder shall offer centrifugal type speed switch mounted on the motor shaft which shall remain closed for speed lower than 19% and open for speeds above 19% of the rated speed. The speed switch shall be capable of withstanding 120% of the rated speed in either direction of rotation.

22.4 Running Requirements:

a) The maximum permissible temperature rise over the ambient temperature of 50 degree C shall be within the limits specified in relevant

International Standard (for 3 - phase induction motors) after adjustment due to increased ambient temperature specified.

b) The double amplitude of motor vibration shall be within the limits specified in relevant International Standard. Vibration shall also be within the limits specified by the relevant standard for the driven equipment when measured at the motor bearings.

c) All the induction motors shall be capable of running at 80% of rated voltage for a period of 5 minutes with rated load commencing from hot condition.

22.5 TESTING AND COMMISSIONING

An indicative list of tests is given below. Contractor shall perform any additional test based on specialties of the items as per the field Q.P./Instructions of the equipment Contractor or Employer without any extra cost to the Employer. The Contractor shall arrange all instruments required for conducting these tests alongwith calibration certificates and shall furnish the list of instruments to the Employer for approval.

(a) Insulation resistance.

(b) Phase sequence and proper direction of rotation.

(c) Any motor operating incorrectly shall be checked to determine the cause and the conditions corrected.

23.0 TECHNICAL REQUIREMENT OF EQUIPMENTS

23.1 LT Switchgear

23.1.1 The Manufacturer who's LT Switchgear are offered, should be a manufacturer of LT Switchboards of the type and rating being offered. He should have designed, manufactured, tested and supplied at least 50 nos. draw out circuit breaker panels, out of which at least 5 nos. should have been with relay and protection schemes with current transformer. He should have also manufactured at least 50 nos MCC panels comprising of MCCBs (ie Moulded Case Circuit Breakers) modules of the type offered which should be in successful operation as on originally Scheduled date of bid opening.

23.1.2 The Switchgear items (such as circuit breakers, fuse switch units, contactors etc.), may be of his own make or shall be procured from reputed manufacturers and of proven design. At least one hundred circuit breakers of the make and type being offered shall be operating satisfactory as on originally Scheduled date of bid opening.

23.2 Fire Fighting System

The bidder or his sub-vendor should have designed, supplied, tested, erected and commissioned at least one number fire protection system of the each type described in (i), (ii) and (iii) below in installations such as power plants, substations, refineries, fertilizer plants or other industrial or commercial installations. Such systems must have been designed and comply to International Standard code (FOC, LONDON or NFPA, USA etc) executed during last ten (10) years and should have been in successful operation for at least 2 years as on the originally Scheduled date of bid opening.

(i) Automatic hydrant type fire protection system.

(ii) Automatic high velocity or automatic medium velocity water spray type fire protection system

(iii) Smoke detection system.

In case bidder himself do not meet the requirement of design, he can engage a consultant(s) who must have designed i) Automatic hydrant type fire protection system, ii) Automatic high velocity or automatic medium velocity water spray type fire protection system and iii) Smoke detection system, which must be in successful operation for at least two years as on the originally Scheduled date of bid opening.

23.3 Power & Control Cables

Must have manufacturing experience of at least 5 (Five) years.

Applicable for PVC Control Cable

Must have designed, manufactured, tested and supplied in a single contract at least 50 Kms of 1.1 KV grade PVC insulated control cables as on the date of bid opening. Further the manufacturer should also have designed, manufactured, tested and supplied at least 1 km of 27C x 2.5 Sq.mm or higher size as on the originally Scheduled date of bid opening.

Applicable for PVC Power Cable

Must have designed, manufactured, tested and supplied in a single contract at least 50 Kms of 1.1 KV or higher grade PVC insulated power cables as on the date of bid opening. Further the manufacturer should also have designed, manufactured, tested and supplied at least 1 km of 1C x 150 Sq. mm or higher size as on the originally Scheduled date of bid opening.

Applicable for XLPE Power Cables

Must have designed, manufactured, tested and supplied in a single contract at least 25 Kms of 1.1 KV or higher grade XLPE insulated power cables as on the date of bid opening. Further the manufacturer should also have designed, manufactured, tested and supplied at least 1 km of 1C x 630 Sq. mm or higher size as on the originally Scheduled date of bid opening.

23.4 Those equipments which are required for the completion of the works under the contract and whose qualifying criterion are not stated in the Bidding Documents, the contractor shall purpose the reputed qualified manufacturers with prior approval from the Employer during the detail engineering.

ANNEXURE-A

CORONA AND RADIO INTERFERENCE VOLTAGE (RIV) TEST

1. General

Unless otherwise stipulated, all equipment together with its associated connectors, where applicable, shall be tested for external corona (for 400kV & above) both by observing the voltage level for the extinction of visible corona under falling power frequency voltage and by measurement of radio interference voltage (RIV) for 132kV above.

2. Test Levels:

The test voltage levels for measurement of external RIV and for corona extinction voltage are listed under the relevant clauses of the specification.

3. Test Methods for RIV:

3.1 RIV tests shall be made according to measuring circuit as per International Special-Committee on Radio Interference (CISPR) Publication 16-1(1993) Part -1. The measuring circuit shall preferably be tuned to frequency with 10% of 0.5 Mhz but other frequencies in the range of 0.5 MHz to 2 MHz may be used, the measuring frequency being recorded. The results shall be in microvolts.

3.2 Alternatively, RIV tests shall be in accordance with NEMA standard Publication No. 107-1964, except otherwise noted herein.

3.3 In measurement of, RIV, temporary additional external corona shielding may be provided. In measurements of RIV only standard fittings of identical type supplied with the equipment and a simulation of the connections as used in the actual installation will be permitted in the vicinity within 3.5 meters of terminals.

3.4 Ambient noise shall be measured before and after each series of tests to ensure that there is no variation in ambient noise level. If variation is present, the lowest ambient noise level will form basis for the measurements. RIV levels shall be measured at increasing and decreasing voltages of 85%, 100%, and 110% of the specified RIV test voltage for all equipment unless otherwise specified. The specified RIV test voltage for 400 kV, 220 KV is listed in the detailed specification together with maximum permissible RIV level in microvolts.

3.5 The metering instruments shall be as per CISPR recommendation or equivalent device so long as it has been used by other testing authorities.

3.6 The RIV measurement may be made with a noise meter. A calibration procedure of the frequency to which noise meter shall be tuned shall establish the ratio of voltage at the high voltage terminal to voltage read by noise meter.

4. Test Methods for Visible Corona

The purpose of this test is to determine the corona extinction voltage of apparatus, connectors etc. The test shall be carried out in the same manner as RIV test described above with the exception that RIV measurements are not required during test and a search technique shall be used near the onset and extinction voltage, when the test voltage is raised and lowered to determine their precise values. The test voltage shall be raised to 110% of specified corona extinction voltage and maintained there for five minutes. In case corona inception does not take place at 110%, test shall be stopped, otherwise test shall be continued and the voltage will then be decreased slowly until all visible corona disappears. The procedure shall be repeated at least 4 times with corona inception and extinction voltage recorded each time. The corona extinction voltage for purposes of determining compliance with the specification shall be the lowest of the four values at which visible corona (negative or positive polarity) disappears. Photographs with laboratory in complete darkness shall be taken under test conditions, at all voltage steps i.e. 85%, 100%, and 110**%**. Additional photographs shall be taken at corona inception and extinction voltages. At least two views shall be photographed in each case using Panchromatic film with an ASA daylight rating of 400 with an exposure of two minutes at a lens aperture of f/5.6 or equivalent. The photographic process shall be such that prints are available for inspection and comparison with conditions as determined from direct observation. Photographs shall be taken from above and below the level of connector so as to show corona on bushing, insulators and all parts of energised connectors. The photographs shall be framed such that test object essentially, fills the frame with no cut-off.

For recording purpose, modern devices utilizing UV recording methods such as image intensifier may also be used.

4.1 The test shall be recorded on each photograph. Additional photograph shall be taken from each camera position with lights on to show the relative position of test object to facilitate precise corona location from the photographic evidence.

4.2 In addition to photographs of the test object preferably four photographs shall be taken of the complete test assembly showing relative positions of all the test equipment and test objects. These four photographs shall be taken from four points equally spaced around the test arrangement to show its features from all sides. Drawings of the laboratory and test set up locations shall be provided to indicate camera positions and angles. The precise location of camera shall be approved by Purchaser's inspector, after determining the best camera locations by trial energisation of test object at a voltage which results in corona.

4.3 The test to determine the visible corona extinction voltage need not be carried out simultaneously with test to determine RIV levels.

4.4 However, both test shall be carried out with the same test set up and as little time duration between tests as possible. No modification on treatment of the sample between tests will be allowed. Simultaneous RIV and visible corona extinction voltage testing may be permitted at the discretion of Purchaser's inspector if, in his opinion, it will not prejudice other test.

5. Test Records:

In addition to the information previously mentioned and the requirements specified as per CISPR or NEMA 107-1964 the following data shall be included in test report:

a) Background noise before and after test.

b) Detailed procedure of application of test voltage.

c) Measurements of RIV levels expressed in micro volts at each level.

d) Results and observations with regard to location and type of interference sources detected at each step.

e) Test voltage shall be recorded when measured RIV passes through 100 microvolts in each direction.

f) Onset and extinction of visual corona for each of the four tests required shall be recorded.

ANNEXURE - B

SEISMIC WITHSTAND TEST PROCEDURE

The seismic withstanding test on the complete equipment (for 132kV and above) shall be carried out alongwith supporting structure.

The Bidder shall arrange to transport the structure from his Contractor's premises/NEA sites for the purpose of seismic withstand test only.

The seismic level specified shall be applied at the base of the structure. The accelerometers shall be provided at the Terminal Pad of the equipment and any other point as agreed by the Purchaser. The seismic test shall be carried out in all possible combinations of the equipment. The seismic test procedure shall be furnished for approval of the Purchaser.

ANNEXURE - C

LIST OF SPECIFICATIONS

GENERAL STANDARDS AND CODES

Nepal Electricity Act – 1992

Nepal Electricity Regulation – 1993

Nepal Electricity Grid Code (NEGC)- 2005

IEC-60060 (Part 1 to P4)	-	High Voltage Test Techniques
IEC 60068	-	Environmental Test
IEC-60117	-	Graphical Symbols
IEC-60156,	-	Method for the Determination of the Electrical Strength of Insulation Oils.
IEC-60270,	-	Partial Discharge Measurements.
IEC-60376	-	Specification and Acceptance of New Sulphur Hexafloride
IEC-60437	-	Radio Interference Test on High Voltage Insulators.
IEC-60507	-	Artificial Pollution Tests on High Voltage Insulators to be used on AC Systems.
IEC-62271-1	-	Common Specification for High Voltage Switchgear & Controlgear Standards.
IEC-60815	-	Guide for the Selection of Insulators in respect of Polluted Conditions.
IEC-60865 (P1 & P2)	-	Short Circuit Current - Calculation of effects.
ANSI-C.1/NFPA.70	-	National Electrical Code
ANSI-C37.90A	-	Guide for Surge Withstand Capability (SWC) Tests
ANSI-C63.21,	-	Specification for Electromagnetic Noise and
C63.3	-	Field Strength Instrumentation 10 KHz to 1 GHZ
C36.4ANSI-C68.1	-	Techniquest for Dielectric Tests
ANSI-C76.1/EEE21	-	Standard General Requirements and Test Procedure for Outdoor Apparatus Bushings.
ANSI-SI-4	-	Specification for Sound Level Metres
ANSI-Y32-2/C337.2	-	Drawing Symbols
ANSI-Z55.11	-	Gray Finishes for Industrial Apparatus and Equipment No. 61 Light Gray
NEMA-107T	-	Methods of Measurements of RIV of High Voltage Apparatus

NEMA-ICS-II	-	General Standards for Industrial Control and Systems Part ICSI-109
CISPR-1	-	Specification for CISPR Radio Interference Measuring Apparatus for the frequency range 0.15 MHz to 30 MHz
CSA-Z299.1-1978h	-	Quality Assurance Program Requirements
CSA-Z299.2-1979h	-	Quality Control Program Requirements
CSA-Z299.3-1979h	-	Quality Verification Program Requirements
CSA-Z299.4-1979h	-	Inspection Program Requirements
IEC: 62271-306	-	Direct connections between power transformer& gas insulated metal enclosed switchgear for rated voltage above 52 kV.
IEEE: 80 (2000)	-	IEEE Guide for safety in AC sub-stations grounding.
CIGRE 44	-	Earthing of GIS-an application guide (Electra No. 151, Dec., 1993).

TRANSFORMERS AND REACTORS

IEC-60076 (Part 1 to 5)	-	Power Transformers
IEC-60214	-	On-Load Tap-Changers.
IEC-60289	-	Reactors.
IEC- 60354	-	Loading Guide for Oil - Immersed power Transformers
IEC-60076-10	-	Determination of Transformer and Reactor Sound Levels
ANSI-C571280	-	General requirements for Distribution, Power and Regulating Transformers
ANSI-C571290	-	Test Code for Distribution, Power and Regulation Transformers
ANSI-C5716	-	Terminology & Test Code for Current Limiting Reactors
ANSI-C5721	-	Requirements, Terminology and Test Code for Shunt Reactors Rated Over 500 KVA
ANSI-C5792	-	Guide for Loading Oil-Immersed Power Transformers upto and including 100 MVA with 55 deg C or 65 deg C Winding Rise
ANSI-CG,IEEE-4	-	Standard Techniques for High Voltage Testing

CIRCUIT BREAKERS

IEC-62271-100	-	High-voltage switchgear and controlgear - Part 100: Alternating current circuit-breakers

IEC-62271-101	-	High-voltage switchgear and controlgear - Part 101: Synthetic testing
IEC-62155	-	Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1 000 V
IEC-62271-110	-	High-voltage switchgear and controlgear - Part 110: Inductive load switching
IEC-62271-109	-	High-voltage switchgear and controlgear - Part 110: Inductive load switching

CURRENT TRANSFORMERS, VOLTAGE TRANSFORMERS AND COUPLING CAPACITOR VOLTAGE TRANSFORMERS

IEC-60044-1	-	Current transformers.
IEC-60044-2	-	Inductive Voltage Transformers.
IEC-60044-5	-	Instrument transformers - Part 5: Capacitor voltage transformers
IEC-60358	-	Coupling capacitors and capacitor dividers.
IEC-60044-4	-	Instrument Transformers: Measurement of Partial Discharges
IEC-60481	-	Coupling Devices for power Line Carrier Systems.
ANSI-C5713	-	Requirements for Instrument transformers
ANSIC92.2	-	Power Line Coupling voltage Transformers
ANSI-C93.1	-	Requirements for Power Line Carrier Coupling Capacitors

BUSHING

IEC-60137	-	Insulated Bushings for Alternating Voltages above 1000V

SURGE ARRESTERS

IEC-60099-4	-	Metal oxide surge arrestors without gaps
IEC-60099-5	-	Selection and application recommendation
ANSI-C62.1	-	IEE Standards for S A for AC Power Circuits
NEMA-LA 1	-	Surge Arresters

CUBICLES AND PANELS & OTHER RELATED EQUIPMENTS

IEC-60068.2.2	-	Basic environmental testing procedures Part 2: Test B: Dry heat
IEC-60529	-	Degree of Protection provided by enclosures.
IEC-60947-4-1	-	Low voltage switchgear and control gear.
IEC-61095	-	Electromechanical Contactors for household and similar purposes.
IEC-60439 (P1 & 2)	-	Low Voltage Switchgear and control gear assemblies
ANSI-C37.19	-	Switchgear Assemblies, including metal enclosed bus.
ANSI-C37.50	-	Test Procedures for Low Voltage Alternating Current Power Circuit Breakers
ANSI-C39	-	Electric Measuring instrument
ANSI-C83	-	Components for Electric Equipment
NEMA-AB	-	Moulded Case Circuit and Systems
NEMA-CS	-	Industrial Controls and Systems
NEMA-PB-1	-	Panel Boards
NEMA-SG-5	-	Low voltage Power Circuit breakers
NEMA-SG-3	-	Power Switchgear Assemblies
NEMA-SG-6	-	Power switching Equipment
NEMA-5E-3	-	Motor Control Centers
1248 (P1 to P9)	-	Direct acting indicating analogue electrical measuring instruments & their accessories.

Disconnecting switches

IEC-62271-102	-	High-voltage switchgear and controlgear - Part 102: Alternating current disconnectors and earthing switches
IEC-60265 (Part 1 & 2)	-	High Voltage switches
ANSI-C37.32	-	Schedule of preferred Ratings, Manufacturing Specifications and Application Guide for high voltage Air Switches, Bus supports and switch accessories
ANSI-C37.34	-	Test Code for high voltage air switches
NEMA-SG6	-	Power switching equipment

Communication Equipment

IEC-60481	-	Coupling Devices for power line carrier systems.
IEC-60495	-	Single sideboard power line carrier terminals
IEC-60683	-	Planning of (single Side-Band) power line carrier systems.

CIGRE	-	Teleprotection report by Committee 34 & 35.
CIGRE	-	Guide on power line carrier 1979.
CCIR	-	International Radio Consultative Committee
CCITT	-	International Telegraph & Telephone Consultative Committee
EIA	-	Electric Industries Association

Protection and control equipment

IEC-60051: (P1 to P9)	-	Recommendations for Direct Acting indicating analogue electrical measuring instruments and their accessories.
IEC-60255 (Part 1 to 23)	-	Electrical relays.
IEC-60297		
(P1 to P4)	-	Dimensions of mechanical structures of the 482.6mm (19 inches) series.
IEC-60359	-	Expression of the performance of electrical & electronic measuring equipment.
IEC-60387	-	Symbols for Alternating-Current Electricity meters.
IEC-60447	-	Man machine interface (MMI) - Actuating principles.
IEC-60521	-	Class 0.5, 1 and 2 alternating current watt hour metres
IEC-60547	-	Modular plug-in Unit and standard 19-inch rack mounting unit based on NIM Standard (for electronic nuclear instruments)
ANSI-81	-	Screw threads
ANSI-B18	-	Bolts and Nuts
ANSI-C37.1	-	Relays, Station Controls etc.
ANSI-C37.2	-	Manual and automatic station control, supervisory and associated telemetering equipment
ANSI-C37.2	-	Relays and relay systems associated with electric power apparatus
ANSI-C39.1	-	Requirements for electrical analog indicating instruments

Motors

IEC-60034 (P1 to P19:)	-	Rotating electrical machines
IEC-Document 2	-	Three phase induction motors
(Central Office) NEMA-MGI	Motors and Generators	

Electronic equipment and components

MIL-21B, MIL-833 & MIL-2750

IEC-60068 (P1 to P5)	-	Environmental testing
IEC-60326 (P1 to P2)	-	Printed boards
		Material and workmanship standards
ASTM	-	Specification and tests for materials

Clamps & connectors

NEMA-CC1	-	Electric Power connectors for sub station
NEMA-CC 3	-	Connectors for Use between aluminium or aluminum-Copper Overhead Conductors

Bus hardware and insulators

IEC-60120	-	Dimensions of Ball and Socket Couplings of string insulator units.
IEC-60137	-	Insulated bushings for alternating voltages above 1000 V.
IEC-60168	-	Tests on indoor and outdoor post insulators of ceramic material or glass for Systems with Nominal Voltages Greater than 1000 V.
IEC-62155	-	Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1 000 V
IEC-60273	-	Characteristices of indoor and outdoor post insulators for systems with nominal voltages greater than 1000V.
IEC-61462	-	Pressurized and un-pressurized insulator for use in electrical equipment with rated voltage greater than 1000V – Definitions, Test methods, acceptance criteria and design recommendations
IEC-60305	-	Insulators for overhead lines with nominal voltage above 1000V-ceramic or glass insulator units for a.c. systems Characteristics of String Insulator Units of the cap and pintype.
IEC-60372 (1984)	-	Locking devices for ball and socket couplings of string insulator units : dimensions and tests.
IEC-60383 (P1 and P2)	-	Insulators for overhead lines with a nominal voltage above 1000 V.
IEC-60433	-	Characteristics of string insulator units of the long rod type.

IEC-60471	-	Dimensions of Clevis and tongue couplings of string insulator units.
ANSI-C29	-	Wet process proelain insulators
ANSI-C29.1	-	Test methods for electrical power insulators
ANSI-C92.2	-	For insulators, wet-process porcelain and toughened glass suspension type
ANSI-C29.8	-	For wet-process porcelain insulators apparatus, post-type
ANSI-G.8	-	Iron and steel hardware
CISPR-7B	-	Recommendations of the CISPR, tolerances of form and of Position, Part 1
ASTM A-153	-	Zinc Coating (Hot-Dip) on iron and steel hardware

Strain and rigid bus-conductor

ASTM-B 230-82	-	Aluminum 1350 H19 Wire for electrical purposes
ASTM-B 231-81	-	Concentric - lay - stranded, aluminum 1350 conductors
ASTM-B 221	-	Aluminum - Alloy extruded bar, road, wire, shape
ASTM-B 236-83	-	Aluminum bars for electrical purpose (Bus-bars)
ASTM-B 317-83	-	Aluminum-Alloy extruded bar, rod, pipe and structural shapes for electrical purposes (Bus Conductors)

Batteries and batteries charger

Battery

IEC:60896-21&22	-	Lead Acid Batteries Valve Regulated types – Methods of Tests & Requirements
IEC: 60623	-	Vented type nickel Cadmium Batteries
IEC:60622	-	Secondary Cells & Batteries – Sealed Ni-Cd rechargeable single cell
IEC:60623	-	Secondary Cells & Batteries – Vented Ni-Cd rechargeable single cell
IEC:60896-11	-	Stationary Lead Acid Batteries – Vented Type – General requirements & method of tests
IEEE-485	-	Recommended practices for sizing of Lead Acid Batteries
IEEE-1115	-	Sizing of Ni-Cd Batteries
IEEE-1187	-	Recommended practices for design & installation of VRLA Batteries

IEEE-1188	-	Recommended practices for design & installation of VRLA Batteries
IEEE-1189	-	Guide for selection of VRLA Batteries

Battery Charger

IEEE-484	-	Recommended Design for installation design and installation of large lead storage batteries for generating stations and substations.
IEEE-485	-	Sizing large lead storage batteries for generating stations and substations

Wires and cables

ASTMD-2863	-	Measuring the minimum oxygen concentration to support candle like combustion of plastics (oxygen index)
IEC-60096 (part 0 to p4)	-	Radio Frequency cables.
IEC-60183	-	Guide to the Selection of High Voltage Cables.
IEC-60189 (P1 to P7)	-	Low frequency cables and wires with PVC insulation and PVC sheath.
IEC-60227 (P1 to P7)	-	Polyvinyl Chloride insulated cables of rated voltages up to and including 450/750V.
IEC-60228	-	Conductors of insulated cables
IEC-60230	-	Impulse tests on cables and their accessories.
IEC-60287 (P1 to P3)	-	Calculation of the continuous current rating of cables (100% load factor).
IEC-60304	-	Standard colours for insulation for low-frequency cables and wires.
IEC-60331	-	Fire resisting characteristics of Electric cables.
IEC-60332 (P1 to P3)	-	Tests on electric cables under fire conditions.
IEC-60502	-	Extruded solid dielectric insulated power cables for rated voltages from 1 kV upto to 30 kV
IEC-754 (P1 and P2)	-	Tests on gases evolved during combustion of electric cables.

Painting

ANSI-Z551	-	Gray finishes for industrial apparatus and equipment
SSPEC	-	Steel structure painting council

HORIZONTAL CENTRIFUGAL PUMPS

API-610	-	Centrifugal pumps for general services
	-	Hydraulic Institutes Standards
BS:599	-	Methods of testing pumps
PTC-8.2	-	Power Test Codes - Centrifugal pumps

DIESEL ENGINES

ASME Power Test Code	-	Internal combustion engine PTC-17
	-	Codes of Diesel Engine Manufacturer's Association, USA

PIPING VALVES & SPECIALITIES

BS:5150	-	Specification for cast iron gate valves

PG Test Procedures

NFPA-13	-	Standard for the installation of sprinkler system
NFPA-15	-	Standard for water spray fixed system for the fire protection
NFPA-12A	-	Standard for Halong 1301 Fire Extinguishing System
NFPA-72E	-	Standard on Antomatic Fire Detectors
NFPA-12	-	Standard on Carbon dioxide extinguisher systems

Electrical generating and distributing stations code of practice

Steel structures

ANSI-B18.2.1	-	Inch series square and Hexagonal bolts and screws
ANSI-B18.2.2	-	Square and hexagonal nuts
ANSI-G8.14	-	Round head bolts
ASTM-A6	-	Specification for General Requirements for rolled steel plates, shapes, sheet piling and bars of structural use
ASTM-A36	-	Specifications of structural steel
ASTM-A47	-	Specification for malleable iron castings
ASTM-A143	-	Practice for safeguarding against embilement of Hot Galvanized structural steel products and procedure for detaching embrilement
ASTM-A242	-	Specification for high strength low alloy structural steel
ASTM-A283	-	Specification for low and intermediate tensile strength carbon steel plates of structural quality
ASTM-A394	-	Specification for Galvanized steel transmission tower bolts and nuts

ASTM-441	-	Specification for High strength low alloy structural manganese vanadium steel.
ASTM-A572	-	Specification for High strength low alloy colombium-Vanadium steel of structural quality
AWS D1-0	-	Code for welding in building construction welding inspection
AWS D1-1	-	Structural welding code
AISC	-	American institute of steel construction
NEMA-CG1	-	Manufactured graphite electrodes

Piping and pressure vessels

ASME	-	Boiler and pressure vessel code
ASTM-A120	-	Specification for pipe steel, black and hot dipped, zinc-coated (Galvanized) welded and seamless steel pipe for ordinary use
ASTM-A53	-	Specification for pipe, steel, black, and hot-dipped, zinc coated welded and seamless
ASTM-A106	-	Seamless carbon steel pipe for high temperature service
ASTM-A284	-	Low and intermediate tensile strength carbon-silicon steel plates for machine parts and general construction.
ASTM-A234	-	Pipe fittings of wrought carbon steel and alloy steel for moderate and elevated temperatures
ASTM-S181	-	Specification for forgings, carbon steel for general purpose piping
ASTM-A105	-	Forgings, carbon steel for piping components
ASTM-A307	-	Carbon steel externally threated standard fasteners
ASTM-A193	-	Alloy steel and stainless steel bolting materials for high temperature service
ASTM-A345	-	Flat rolled electrical steel for magnetic applications
ASTM-A197	-	Cupola malleable iron
ANSI-B2.1	-	Pipe threads (Except dry seal)
ANSI-B16.1	-	Cast iron pipe flangesand glanged fitting. Class 25, 125, 250 and 800
ANSI-B16.1	-	Malleable iron threaded fittings, class 150 and 300
ANSI-B16.5	-	Pipe flanges and flanged fittings, steel nickel alloy and other special alloys
ANSI-B16.9	-	Factory-made wrought steel butt welding fittings

ANSI-B16.11	-	Forged steel fittings, socket-welding and threaded
ANSI-B16.14	-	Ferrous pipe plug, bushings and locknuts with piplethreads
ANSI-B16.25	-	Butt welding ends
ANSI-B18.1.1	-	Fire hose couplings screw thread.
ANSI-B18.2.1	-	Inch series square and hexagonal bolts and screws
ANSI-B18.2.2	-	Square and hexagonal nuts
NSI-B18.21.1	-	Lock washers
ANSI-B18.21.2	-	Plain washers
ANSI-B31.1	-	Power piping
ANSI-B36.10	-	Welded and seamless wrought steel pipe
ANSI-B36.9	-	Stainless steel pipe

ACSR MOOSE CONDUCTOR

IEC:437-1973	Test on High Voltage Insulators NEMA:107-1964 CISPR
Part - V	Overhead Transmission Purposes
BS:215(Part-II)	Aluminium Conductors galvanized IEC:209-1966 steel reinforced extra high
BS:215(Part-II)	voltage (400 kV and above)

GALVANISED STEEL EARTHWIRE

P5:1992)	overhead transmission purposes.

TRANSFORMERS & REACTORS

IEC 60076	Power transformers
IEC 60076-1	Part 1: General
IEC 60076-2	Part 2: Temperature rise
IEC 60076-3	Part 3: Insulation levels, dielectric tests and external clearances in air
IEC 60076-4	Part 4: Guide to the lightning impulse and switching impulse testing - Power transformers and reactors
IEC 60076-3-1	Part 3-1: Insulation Levels and Dielectric Tests – External Clearances in Air
IEC 60076-5	Part 5: Ability to withstand short circuit
IEC 60076-6	Part 6: Reactors
IEC 60076-7	Part 7: Loading guide for oil-immersed power transformers
IEC 60076-8	Part 8: Application guide

IEC 60076-10	Part 10: Determination of sound levels
IEC 60076-10-1	Part 10-1: Determination of sound levels - Application guide
IEC 60076-11	Part 11: Dry-type transformers
IEC 60076-12	Part 12: Loading guide for dry-type power transformers
IEC 60076-13	Part 13: Self-protected liquid-filled transformers
IEC 60076-14	Part 14: Design and application of liquid-immersed power transformers using high-temperature insulation materials
IEC 60076-15	Part 15: Gas-filled power transformers
IEC 60076-16	Part 16: Transformers for wind turbine applications
IEC 60076-18	Part 18: Measurement of frequency response
IEC 60076-19	Part 19: Rules for the determination of uncertainties in the measurement of losses in power transformers and reactors
IEC 60076-21	Part 21: Standard requirements, terminology, and test code for step-voltage regulators
IEC 60044	Current transformers
IEC 60050	International Electrotechnical Vocabulary
IEC 60050(421)	International Electrotechnical vocabulary- Chapter 421 : Power Transformers and Reactors
IEC 60060	High Voltage test techniques
IEC 60060-1	General definitions and test requirements
IEC 60060-2	Measuring systems
IEC 60071	Insulation co-ordination
IEC 60071-1	Part 1: Definitions, principles and rules
IEC 60071-2	Part 2 : Application guide
IEC 60137	Bushing for alternating voltage above 1000V
IEC 60214	On-Load Tap changers
IEC 255-21-3	Relays vibration
IEC 60270	Partial discharge measurements
IEC 60296	Specification for Unused Mineral Oil for Transformers and Switchgear
IEC 60422	Supervision and Maintenance guide for Mineral Insulating Oil in Electrical Equipment
IEC 60475	Method of Sampling Liquid dielectrics
IEC 60529	Classification of Degrees of Protection provided by Enclosures
IEC 60542	Application Guide for On-Load Tap-Changers
IEC 60567	Guide for the Sampling of Gases and of Oil from Oil-filled Electrical Equipment for the Analysis of Free and Dissolved Gases
IEC 60651	Sound Level Meters
IEC 61083	Digital Recorders and Software for High Voltage Impulse testing

IEC 61083-1	Part 1: Requirements for digital recorders in high voltage impulse tests
IEC 61083-2	Part 2: Evaluation of software used for the determination of the parameters of impulse waveforms
CISPR 16	Specification for radio disturbance and immunity measuring apparatus
CISPR 16-1	Radio disturbance and immunity measuring apparatus
CISPR-18	Radio Interference Characteristics of Power Lines and High Voltage Equipment
ISO 9001	Quality system-Model for Quality Assurance in Design /development
CIGRE Publication 202	Guidelines for conducting design reviews for transformers 100 MVA and 123 kV and above. August 2002-Cigre Working Group 12.22
WG 12-15	Guide for Customers Specifications for Transformers 100 MVA and 123 kV and above
WG 12 19	Short Circuit Performance of Transformers.
BS-4360	Specification for weldable structural steel
BS-5135	Specification for arc welding of carbon and carbon manganese steels
BS-5500	Specification for unfired fusion welded pressure vessels
ISO-8501	Preparation of steel surface before application of Paints and related product
IEC-60599	Mineral oil impregnated electrical equipment in service – guide to the interpretation of dissolved and free gases analysis
IEC-60034-5	Degrees of protection provided by integral design of rotating electrical machines(IP Code) classification
IEC-62271-203	Gas insulated metal enclosed switchgear for rated voltage above 52kV
IEC-61639	Direct connection between power transformers and gas-insulated metal enclosed switchgear for rated voltages of 52.5 kV and above.
IEC 60529 / IP : 55	Degree of protection for cooler control cabinet , MOLG ,Cooling fan , oil pump, Buchholz Relay
IEC 60529 / IP : 56	Degree of protection for Pressure Relief Device
IEC 60529 / IP : 43	Degree of protection for Remote tap Changer cubicle (RTCC)

ANNEXURE - D

S.N.	LIST OF DRAWINGS/DOCUMENTS
1	Single Line Diagram
2	Electrical Layout – Plan and Sections
3	Tower, Equipment & cable trench layout drawing
4	Earthing system design calculation & layout drawing
5	Lighting protection system design & drawings
6	Structure Layout (Plan & Section) drawing
7	Cantilever Strength calculations (if applicable)
8	Design calculation for Sag – Tension stringing chart
9	GTP and drawings for Bus-Post Insulator
10	Tension/suspension string insulator and Hardware Assembly GTP and drawing
11	Soil Investigation Report (if applicable)
12	Circuit Breakers (220kV,132kV, 33 kV- As applicable) - GA drawing, GTP, Type test Reports
13	CTs & CVTs (220kV,132 kV, 33kV- As applicable) - GA drawing, GTP, Type test Reports
14	Surge Arrestors (216kV,120kV, 30kV- As applicable) - GA drawing, GTP, Type test Reports
15	Isolators (220kV,132kV, 33 kV- As applicable) - GA drawing, GTP, Type test Reports
16	Control, Relay Panels and Substation Automation system - GTP, technical literature, type test reports
17	Communication Equipment, Digital Protection Coupler - GTP and technical literature, type test reports
18	Civil Works (as applicable) **a)** GIS Hall Building Structure Design, Foundation Design & Drg., Plinth Beam Design & Drg. and column Design & Drg. upto G.F. Level **b)** Auto transformer foundation design/drawings **c)** Reactor foundation design/drawings **d)** 400/220/33kV Tower, structure & foundation design/drawings. **e)** 400/220/33kV Equipment support structure & foundation design/drawing
19	**Indicative List Of Drawings For Transformer & Reactor**

i. Outline General Arrangement (OGA)drawing of transformer & reactor
   a) Plan
   b) Elevation
   c) End View
   d) Neutral formation of three phase bank

   List of all accessories with detailed weights, dimensions, clearances, spacing of wheels in direction, center of gravity, location of cooler etc.

ii. Foundation Plan showing reaction at points of support, clamping arrangement & location of jacking pads.

iii. Technical Data requirement sheet of transformer & reactor
iv. Over fluxing withstand duration curve
v. Schematic wiring and diagram of cooling arrangement along with write up on scheme
vi. Schematic wiring and diagram of OLTC along with write up on scheme
vii. Mounting Arrangement and wiring diagram of remote WTI along with write up
viii. Bushing Drawing showing electrical and mechanical characteristics
   a) HV Bushing
   b) LV Bushing
   c) Neutral bushing
ix. Outline and General Arrangement of Cooler Control Cabinet
x. Cooler Control cabinet schematic and wiring diagram
xi. Magnetisation Characteristics of bushing CTs
xii. Hysteresis Characteristics of iron core
xiii. Rating and Diagram Plate
xiv. Overall Transport dimension Drawing of transformer & reactor
xv. Drawing showing typical sectional view of the windings with details of insulation, cooling circuit method of cooling and core construction etc.
xvi. Oil Flow Diagram
xvii. Valve Schedule Plate drawing
xviii. Twin Bi-directional Roller
xix. Connection Diag. of all protective devices to marshalling box showing physical location
xx. List of spares
xxi. Technical Literature on all fittings and accessories.
xxii. Calculation to support short circuit withstand capacity of transformer & reactor
xxiii. Calculation of hot spot temperature
xxiv. Value of air core reactance with a typical write-up of calculation
xxv. Oil sampling Bottle details
xxvi. Typical heating and cooling curves
xxvii. OGA of Digital RTCC panel
xxviii. **Digital RTCC panel schematic and wiring diagram**
xxix. **Outline and General Arrangement drawing of Common Marshalling Box**
xxx. **Schematic wiring and diagram of Common Marshalling Box**
xxxi. **OGA of Ladder for transformer & Reactor**
xxxii. **Transformer oil storage tank drawing**
xxxiii. **33 KV Neutral CT drawing and technical data sheet**
xxxiv. Customer inspection schedule
xxxv. Test procedure of transformer & reactor
xxxvi. Type test Reports of transformer & reactor
xxxvii. O & M manual of transformer & reactor

NOTE:

1. The above list of drawing/document is only illustrative and not exhaustive. The contractor shall submit drawings/documents as per requirement of Technical specification.

CHAPTER 3: GAS INSULATED SWITCHGEARS (GIS)

1. GENERAL CHARACTERISTICS

1.1. The SF6 gas insulated metal enclosed switchgear shall be totally safe against inadvertent touch of any of its constituent parts. It should be designed for indoor application with meteorological conditions at site as per Chapter 1-PSR.

1.2. All parts of the switchgear and the bus ducts (for both indoor and outdoor applications) shall be single phase enclosed for 400 kV, single phase/three phase enclosed for 220kV and three phase enclosed for 132 KV.

1.3. The design should be such that all parts subjected to wear and tear are easily accessible for maintenance purposes. The equipment offered shall be protected against all types of voltage surges and any equipment necessary to satisfy this requirement shall be deemed to be included.

1.4. The required overall parameters of GIS are as follows:-

S.N.	Technical particulars	400 kV System	220 kV System	132KV system
1.	Rated Voltage (RMS)	420 kV	245 kV	145 kV
2.	Rated frequency	50 HZ	50 HZ	50 HZ
	Grounding	Effectively earthed	Effectively earthed	Effectively earthed
3.	Rated power frequency withstand Voltage (1 min) line to earth (rms)	650 kV	460 kV	275 kV
4.	Impulse withstand BIL (1.2/50/mic. Sec) Line to earth	±1425 kVp	±1050 kVp	±650 kVp
5.	Switching impulse voltage (250/2500 mic.- sec)	±1050 kVp	-	-
6.	Rated short time withstand current (1 sec) (As applicable)	63/50/ 40 kA (rms))	50/ 40 kA (rms)	31.5kA (rms)
7.	Rated peak withstand current (as applicable)	157.5/125/100 kA (peak)	125/100 kA (peak)	78.75kA (peak)
8.	Rated current (at 50 degree C design ambient temperature)	As per Bid Price schedule		

2. REFERENCE STANDARDS

The metal-enclosed gas-insulated switchgear, including the operating devices, accessories and auxiliary equipment forming integral part thereof, shall be designed, manufactured, assembled and tested in accordance with the following International Electro-technical Commission (IEC) Publications including their parts and supplements as amended or revised as on date of bid opening:

IEC 62271-203	Gas Insulated metal-enclosed switchgear for rated voltages Above 52 KV
IEC 62271-207	Seismic qualification for gas-insulated switchgear assemblies for rated voltages above 52 kV
IEC 60376	New sulphur hexafluoride
IEC 62271- 100	High voltage alternating current Circuit breakers
IEC 62271-1	Common clauses for high voltage Switchgear and control-gear standards
IEC 62271-102	Alternating current disconnectors (isolators) and earthing switches
IEC 60044-1	Current transformers
IEC 60044-2	Voltage transformers
IEC 60137	Bushings for alternating voltages above 1000 V
IEC 62271-209	Cable connections for gas-insulated switchgear
IEC 60480	Guide to checking of sulphur hexafluoride taken from electrical equipment
IEC 60099 -1/4	Non-linear resistor type arresters for AC systems
IEC 60439	Factory-built assemblies of low-voltage switchgear and Control Gear.
IEEE 80 (2000)	IEEE Guide for Safety in AC Substation grounding.
CIGRE-44	Earthing of GIS- an application guide. (Electra no.151, Dec'93).
IEC 61639	Direct connection between Power Transformers and gas insulated metal enclosed switchgear for rated voltage 72.5 kV and above.

The components and devices which are not covered by the above standards shall conform to, and comply with, the applicable standards, rules, codes and regulations of the internationally recognized standardizing bodies and professional societies as may be approved by the Employer and the manufacturer shall list all such applicable standards, codes etc.

In case the requirements laid down herein differ from those given in above standard in any aspect the switchgear shall comply with the requirements indicated herein in regard thereto.

3. DEFINITIONS

3.1. **Assembly:** Assembly refers to the entire completed GIS equipment furnished under contract.

3.2. **Bay:** Bay refers to the area occupied by one Circuit Breaker and associated Equipment.

3.3. **Compartment:** When used in conjunction with GIS equipment, compartment refers to a gas tight volume bounded by enclosure walls and gas tight isolating barriers.

3.4. **Enclosure:** When used in conjunction with GIS equipment, enclosure refers to the grounded metal housing or shell which contains and protects internal Power system equipment (breaker, disconnecting switch, grounding switch, voltage transformer, current transformer, surge arresters, interconnecting bus etc.)

3.5. **Manual Operation:** Manual operation means operation by hand without using any other source of power.

3.6. **Module:** When used in conjunction with GIS equipment, module refers to a portion of that equipment. Each module includes its own enclosure. A module can contain more than one piece of equipment, for example, a module can contain a disconnecting switch and a grounding switch.

3.7. **Reservoir**: When used in conjunction with GIS equipment reservoir refers to a larger gas-tight volume.

4. GENERAL DESIGN AND SAFETY REQUIREMENT

4.1. The GIS shall be designed, manufactured and tested in accordance with the best international engineering practices under strict quality control to meet the requirement stipulated in the technical specification. Adequate safety margin with respect to thermal, mechanical, dielectric stress and insulation coordination etc. shall be maintained during design, selection of raw material, manufacturing process etc. so that the GIS provides long life with least maintenance.

The workmanship shall be of the highest quality and shall conform to the latest modern practices for the manufacture of high technology machinery and electrical switchgear.

4.2. The GIS assembly shall consist of separate modular compartments e.g. Circuit Breaker compartment, Bus bar compartment filled with SF6 Gas and separated by gas tight partitions so as to minimize risk to human life, allow ease of maintenance and limit the effects of gas leaks failures & internal arcs etc. These compartments shall be such that maintenance on one feeder may be performed without de-energising the adjacent feeders. These compartments shall be designed to minimize the risk of damage to adjacent sections and protection of personnel in the event of a failure occurring within the compartments. Rupture diaphragms with suitable deflectors shall be provided to prevent uncontrolled bursting pressures developing within the enclosures under worst operating conditions, thus providing controlled pressure relief in the affected compartment.

4.3. The switchgear, which shall be of modular design, shall have complete phase isolation. The conductors and the live parts shall be mounted on high graded epoxy resin insulators. These insulators shall be designed to have high structural strength and electrical dielectric properties and shall be free of any voids and free of partial discharge at a voltage which is at least 5% greater than the rated voltage. These shall be designed to have high structural and dielectric strength properties and shall be shaped so as to provide uniform field distribution and to minimize the effects of particle deposition either from migration of foreign particles within the enclosures or from the by-products of SF6 breakdown under arcing conditions.

4.4. Gas barrier insulators shall be provided so as to divide the GIS into separate compartments. These shall be suitably located in order to minimize disturbance in case of leakage or dismantling. They shall be designed to withstand any internal fault thereby keeping an internal arc inside the faulty compartment. Due to safety requirement for working on this pressurized equipment, whenever the pressure of the adjacent gas compartment is reduced during maintenance, this compartment shall be designed so that it shall remain in service to perform its intended duty. The gas tight barriers shall be clearly marked on the outside of the enclosures.

The bus enclosure should be sectionalized in a manner that maintenance work on any bus disconnector (when bus and bus disconnector are enclosed in a single enclosure) can be carried out by isolating and evacuating the small effected section and not the entire bus. The design of the 400 kV GIS shall be such that in case one circuit breaker module is removed for maintenance, there is no disruption in the power flow in any of the two circuits in the diameter. The design of 220 kV GIS shall be such that in case a circuit breaker module of a feeder is removed for maintenance, both busbars shall remain in service. Further the design of 132kV GIS shall be such that that in case a circuit breaker module of a feeder is removed for maintenance, the bus bar shall remain in service. For achieving the above requirements, adequate Mechanical support and number of intermediate gas tight compartments as required, shall be provided to ensure equipment and operating personnel's safety.

4.5. The material and thickness of the enclosures shall be such as to withstand an internal flash over without burn through for a period of 300 ms at rated short time withstand current. The material shall be such that it has no effect of environment as well as from the by-products of SF6 breakdown under arcing condition.

4.6. Each section shall have plug- in or easily removable connection pieces to allow for easy replacement of any component with the minimum of disturbance to the remainder of the equipment. Inspection windows shall be provided for Disconnectors and earth switches.

4.7. The material used for manufacturing the switchgear equipment shall be of the type, composition and have physical properties best suited to their particular purposes and in accordance with the latest engineering practices. All the conductors shall be fabricated of aluminum/ copper tubes of cross sectional area suitable to meet the normal and short circuit current rating requirements. The finish of the conductors shall be smooth so as to prevent any electrical discharge. The conductor ends shall be silver plated and fitted into finger contacts or tulip contacts. The contacts shall be of sliding type to allow the conductors to expand or contract axially due to temperature variation without imposing any mechanical stress on supporting insulators.

4.8. Each pressure filled enclosure shall be designed and fabricated to comply with the requirements of the applicable pressure vessel codes and based on the design temperature and design pressures as defined in IEC-62271-203.

4.9. The maximum SF6 gas leakage shall not exceed 0.5% (half percent) per year for the whole equipment and for any individual gas compartment separately. The SF6 gas leakage should not exceed 0.5% per year and the leakage rate shall be guaranteed for at least 10 years. In case the leakage under the specified conditions is found to be greater than 0.5% after one year of commissioning, the manufacturer will have to supply free of cost, the total gas requirement for subsequent ten (10) years, based on actual leakage observed during the first year of operation after commissioning

4.10. Each gas-filled compartment shall be equipped with static filters, density switches, filling valve and safety diaphragm. The filters shall be capable of absorbing any water vapor which may penetrate into the enclosures as well as the by-products of SF6 during interruption. Each gas compartment shall be fitted with non-return valve connectors for evacuating & filling the gas and checking the gas pressure etc.

4.11. The switchgear line-up when installed and operating under the ambient conditions shall perform satisfactorily and safely under all normal and fault conditions. Even repeated operations up to the permissible servicing intervals under 100% rated and fault conditions shall not diminish the performance or significantly shorten the useful life of the switchgear. Any fault caused by external reasons shall be positively confined to the originating compartment and shall not spread to other parts of the switchgear.

4.12. The thermal rating of all current carrying parts shall be minimum for one sec. for the rated symmetrical short-circuit current.

4.13. The switchgear shall be of the free standing, self-supporting with easy accessibility to all the parts during installation & maintenance with all high-voltage equipment installed inside gas-insulated metallic and earthed enclosures, suitably sub-divided into individual arc and gas-proof compartments preferably for:

1) Bus bars
2) Intermediate compartment
3) Circuit breakers
4) Line Disconnectors
5) Voltage Transformers
6) Gas Insulated bus duct section between GIS and XLPE cable/Overhead Conductor.
7) Gas Insulated bus section between GIS & Oil filled Transformer/ Reactor (if applicable)

4.14. The arrangement of the individual switchgear bays shall be such so as to achieve optimum space-saving, neat and logical arrangement and adequate accessibility to all external components.

4.15. The layout of the substation equipment, bus bars and switchgear bays shall preferably be based on the principle of "phase grouping". Switchgear layout based on the "mixed phases" principle shall not be accepted without mutual agreement between supplier and employer. The arrangement of the equipment offered must provide adequate access for operation, testing and maintenance.

4.16. All the elements shall be accessible without removing support structures for routine inspections. The removal of individual enclosure parts or entire breaker bays shall be possible without disturbing the enclosures of neighboring bays.

4.17. It should be impossible to unwillingly touch live parts of the switchgear or to perform operations that lead to arcing faults without the use of tools or brute force. All interlocks that prevent potentially dangerous mal-operations, shall be constructed such that they cannot be operated easily, i.e. the operator must use tools or brute force to over-ride them.

4.18. In general the contours of energized metal parts of the GIS and any other accessory shall be such, so as to eliminate areas or points of high electrostatic flux concentrations. The surfaces shall be smooth with no projection or irregularities which may cause visible corona.

No corona shall be visible in complete darkness which the equipment is subjected to specified test voltage. There shall be no radio interference from the energized switchgear at rated voltage.

4.19. The GIS shall be designed, so as to take care of the VFT over voltages generated as a result of pre-strikes and re-strikes during isolator operation. Maximum VFT over voltages peak shall not be higher than rated lightning impulse withstand voltage (LIWV) of the equipment. Necessary measures shall be under taken by GIS manufacture to restrict maximum VFT over voltages lower than the LIWV. Manufacturer shall submit the study report of VFTO generated for GIS installation.

4.20. The enclosure shall be of continuous design and shall meet the requirement as specified in clause no. 10 (special considerations for GIS) of IEEE- 80, Year- 2000.

The enclosure shall be sized for carrying induced current equal to the rated current of the Bus. The conductor and the enclosure shall form the concentric pair with effective shielding of the field internal to the enclosure.

4.21. The fabricated metal enclosures shall be of Aluminum alloy having high resistance to corrosion, low electrical loses and negligible magnetic losses. All joint surfaces shall be machined and all castings shall be spot faced for all bolt heads or nuts and washers. All screws, bolts, studs and nuts shall conform to metric system.

4.22. The elbows, bends, cross and T-sections of interconnections shall include the insulators bearing the conductor when the direction changes take place in order to ensure that live parts remain perfectly centered and the electrical field is not increased at such points.

4.23. The enclosure shall be designed to practically eliminate the external electromagnetic field and thereby electro-dynamic stresses even under short circuit conditions. The average intensity of electromagnetic field shall not be more than 50 micro –Tesla on the surface of the enclosure. The contractor shall furnish all calculations and documents in support of the above during detailed engineering.

4.24. The switchgear shall have provision for connection with ground mat risers. This provision shall consist of grounding pads to be connected to the ground mat riser in the vicinity of the equipment.

4.25. The ladders and walkways shall be provided wherever necessary for access to the equipment.

4.26. Wherever required, the heaters shall be provided for the equipment in order to ensure the proper functioning of the switchgear at specified ambient temperatures. The heaters shall be rated for 230V AC supply and shall be complete with thermostat, control switches and fuses, connected as a balanced 3-phase. 4-wire load. The heaters shall be so arranged and protected as to create no hazard to adjacent equipment from the heat produced.

4.27. The enclosure & support structure shall be designed that person of 1780 mm in height and 80 Kg in weight is able to climb on the equipment for maintenance.

4.28. The sealing provided between flanges of two modules / enclosures shall be such that long term tightness is achieved.

4.29. Alarm circuit shall not respond to faults for momentary conditions. The following indications including those required elsewhere in the specifications shall be generally provided in the alarm and indication circuits.

Gas Insulating System:

i) Loss of Gas Density.
ii) Loss of Heater power(if required)
iii) Any other alarm necessary to indicate deterioration of the gas insulating system.

Operating System:

i) Low operating pressure.
ii) Loss of Heater power.
iii) Loss of operating power.
iv) Loss of control supply.
v) Pole Discordance.

4.30. The equipment will be operated under the following ambient conditions(or as defined in the Chapter 1-PSR):

a) The ambient temperature varies between 0 degree-C and 50 degree-C. However, for design purposes, ambient temperature should be considered as 50 degree-C.
b) The humidity will be about 95% (indoors)
c) The elevation is less than 1000 metres

4.31. Temperature rise of current carrying parts shall be limited to the values stipulated in IEC-62271-1, under rated current and the climatic conditions at site. The temperature rise for all enclosures shall not exceed 20 degree C above the ambient temperature of 50 degree C. These conditions shall be taken into account by the supplier in the design of the equipment

4.32. **Bellows or Compensating Units:-** Adequate provision shall be made to allow for the thermal expansion of the conductors & enclosures and of differential thermal expansion between the conductors and the enclosures. The bellows metallic(preferably stainless steel) with suitable provision for permitting the movement during expansion and contraction may be provided and shall be of following types:.

1. Lateral / Vertical mounting units: These shall be inserted, as required, between sections of busbars, on transformer, shunt reactor and XLPE cable etc. Lateral mounting shall be made possible by a sliding section of enclosure and tubular conductors.

2. Axial compensators: These shall be provided to accommodate changes in length of busbars due to temperature variations.

3. Parallel compensators: These shall be provided to accommodate large linear expansions and angle tolerances.

4. Tolerance compensators: These shall be provided for taking up manufacturing, site assembly and foundation tolerances.

5. Vibration compensators: These bellow compensators shall be provided for absorbing vibrations caused by the transformers and shunt reactors when connected to SF6 switchgear by oil- SF6 bushings.

The electrical connections across the bellows or compensating units shall be made by means of suitable connectors. For sliding type compensators, markers/pointers shall be provided to observe expansion or contraction during climatic conditions.

4.33. **Indication and verification of switch positions**: Indicators shall be provided on all circuit breakers, isolators and earth-switches, which shall clearly show whether the switches are open or closed. The indicators shall be mechanically coupled directly to the main contact operating drive rod or linkages and shall be mounted in a position where they are clearly visible from the floor or the platform in the vicinity of the equipment.

Inspection windows shall also be provided with all isolators and earth switches so that the switch contact positions can be verified by direct visual inspection.

4.34. **Pressure relief device** : Pressure relief devices shall be provided in the gas sections to protect the gas enclosures from damage or distortion during the occurrence of abnormal pressure increase or shock waves generated by internal electrical fault arcs (preferably in downward direction).

Pressure relief shall be achieved either by means of diaphragms or plugs venting directly into the atmosphere in a controlled direction.

If the pressure relief devices vent directly into the atmosphere, suitable guards and deflectors shall be provided. Contractor shall submit to the owner the detailed criteria/ design regarding location of pressure relief devices/rupture diaphragms.

4.35. **Pressure vessel requirements**: The enclosure shall be designed for the mechanical and thermal loads to which it is subjected in service. The enclosure shall be manufactured and tested according to the pressure vessel code (ASME/CENELEC code for pressure Vessel.)

The bursting strength of Aluminum castings has to be at least 5 times the design pressure. A bursting pressure test shall be carried out at 5 times the design pressure as a type test on each type of enclosure.

Each enclosure has to be tested as a routine test at 1.5 times the design pressure for one minute.

4.36. **Grounding:**

4.36.1. The grounding system shall be designed and provided as per IEEE-80-2000 and CIGRE-44 to protect operating staff against any hazardous touch voltages and electro-magnetic interferences.

4.36.2. The GIS supplier shall define clearly what constitutes the main grounding bus of the GIS. The contractor shall supply the entire material for grounding bus of GIS viz conductor, clamps, joints, operating and safety platforms etc. The contractor is also required to supply all the earthing conductors and associated hardware material for connecting all GIS equipment, bus ducts, enclosures, control cabinets, supporting structure, GIS surge arrestor etc. to the ground bus of GIS.

4.36.3. The enclosure of the GIS may be grounded at several points so that there shall be grounded cage around all the live parts. A minimum of two nos. of grounding connections should be provided for each of circuit breaker, cable terminals, surge arrestors, earth switches and at each end of the bus bars. The grounding continuity between each enclosure shall be effectively interconnected externally with Copper /Aluminum bonds of suitable size to bridge the flanges. Subassembly to subassembly bonding shall be provided to bridge the gap & safe voltage gradients between all intentionally grounded parts of the GIS assembly & between those parts and the main grounding bus of the GIS.

4.36.4. Each marshaling box, local control panel, power and control cable sheaths and other non-current carrying metallic structures shall be connected to the grounding system of GIS via connections that are separated from GIS enclosures.

4.36.5. The grounding connector shall be of sufficient mechanical strength to withstand electromagnetic forces as well as capable of carrying the anticipated maximum fault current without overheating. At least two grounding paths shall be provided to connect each point to the main grounding bus. Necessary precautions should be under taken to prevent excessive currents from being induced into adjacent frames, structures of reinforcing steel and to avoid establishment of current loops via other station equipment.

4.36.6. All flexible bonding leads shall be tinned copper. All connectors, for attaching flexible bonding leads to grounding conductors and grounding conductors to support structures shall be tinned bronze with stainless steel or tinned bronze hardware.

4.36.7. The contractor shall provide suitable measure to mitigate transient enclosure voltage caused by high frequency currents caused by lightning strikes, operation of surge arrestor, phase to earth fault and discharges between contacts during switching operation. The grounding system shall ensure safe touch & step voltages in all the enclosures.

4.37. **UHF sensors for PD detection**: Contractor shall provide adequate number of UHF sensors in the offered GIS for detection of Partial discharge (of 5 pC and above) as per IEC 60270 through Partial Discharge (PD) monitoring system and the number and location of these sensors shall be subject to approval of the employer. Further UHF sensors shall necessarily be provided in close proximity to VT compartments

However adequacy of number of sensors and their location shall be verified at site by the contractor as per recommendations of CIGRE task force TF 15/33.03.05 (**Task force on *Partial discharge detection system for GIS: Sensitivity verification for the UHF method and the acoustic method***). In case during site testing additional UHF sensors are required, the same shall also be supplied& installed to complete the technical requirement.

4.38. **Gas Insulated Bus (GIB) layout:**

GIB shall be designed based on the following criteria

(1) Maximum weight of gas in a gas tight section of GIB shall not exceed 400 Kg (for 400 kV)/ 250 Kg (for 220 kV & 132 kV).

(2) GIS bus ducts of each circuit shall be arranged in preferably horizontal formation and the clearance (outer to outer) between nearest bus ducts of two adjacent circuits shall be minimum one (1) meter.

(3) GIB shall be generally in only one horizontal layer. However in exceptional circumstance two horizontal GIB layers can be provided with the approval of Owner and the vertical clearance between layers shall be minimum one (1) meter in such case.

(4) The minimum outer to outer horizontal clearance between each GIS bus duct shall be 0.75 meter for 400 kV voltage level and 0.5 meter for 220 kV & 132 kV voltage level.

(5) The minimum vertical ground clearance of GIB at road crossing shall be 5.5 meters.

(6) The horizontal clearance between GIB and GIS building /any other building wall shall be minimum three (3) meters.

(7) The GIB route inside the GIS Hall shall not obstruct easy access to GIS and control room buildings and shall not obstruct movement of crane, equipment including HV test equipment for maintenance works.

(8) The GIB height outside the GIS hall in switchyard area shall not obstruct easy access to GIB, movement of crane for maintenance work.

(9) Optimization of outdoor GIB length using overhead AIS connection with Bus Post Insulator of respective voltage class is generally acceptable subject to meeting the electrical clearances as stipulated.

(10) For the maintenance of GIB of one circuit, only that circuit shall be isolated

4.39. A portable ladder with adjustable height shall be supplied to access the GIS equipment for O&M purpose.

4.40. **Extension of GIS**

4.40.1. The arrangement of gas sections or compartments shall be such as to facilitate future extension of any make without any drilling, cutting or welding on the existing equipment. To add equipment, it shall not be necessary to move or dislocate the existing switchgear bays.

4.40.2. As the GIS is likely to be extended in future, the contractor shall make available during detailed engineering stage, the complete design detail of interface module such as cross section, enclosure material, enclosure dimensions (inner & outer), Flange diameter (inner & outer), conductor connection arrangement, bolt spacing & dimension, rated gas pressure etc. Further GIS manufacturer supplying GIS under present scope shall furnish all the required details in addition to mentioned above necessary for design and successful implementation of an interface module during later stage while extending GIS by any other GIS manufacturer, without any help of GIS manufacturer who has supplied the GIS equipment in present scope.

4.40.3. The Interface module shall be designed to provide Isolating link with access hole on enclosure. The Isolating link shall be provided in such a way so that HV test can be performed on either side of the interface module separately, keeping other side of GIS remain isolated.

4.40.4. Further the contractor who is extending the existing GIS installation shall optimally utilize the space inside the GIS hall (including the extension portion) for accommodating the interface module being supplied under the contract and the space (along the length of the hall) inside the GIS hall for interface module shall preferably be limited to 2 meter for 400kV and 1 meter for 220/132kV.

4.41. **SF6 GAS**

The SF6 gas insulated metal-clad switchgear shall be designed for use with SF6 gas complying with the **recommendations** of IEC 376, 376A & 376B, at the time of the first charging with gas. All SF6 gas supplied as part of the contract shall comply with the requirements of IEC as above as a minimum & should be suitable in all respects for use in the switchgear under all operating conditions.

The high pressure cylinders in which SF6 gas is supplied & stored at site shall comply with the requirements of following standards & regulations:

IS : 4379 or equivalent

Identification of the contents of industrial gas cylinders

IS : 7311 or equivalent

Seamless high carbon steel cylinders for permanent & high pressure liquefiable gases.

SF6 gas shall be tested for purity, dew point, air, hydrolysable fluorides and water contents as per IEC:376, 376A & 376B and test certificates shall be furnished to the owner indicating all test results as per IEC standards for each lot of SF6 gas. Further site tests for moisture, air content, flash point and dielectric strength to be done during commissioning of GIS. Gas bottles should be tested for leakage during receipt at site.

The contractor shall indicate diagnostic test methods for checking the quality of gas in the various sections during service. The method proposed shall, as a minimum check the moisture content & the percentage of purity of the gas on annual basis.

The contractor shall also indicate clearly the precise procedure to be adopted by maintenance personnel for handling equipment that are exposed to the products of arcing in SF6 Gas so as to ensure that they are not affected by possible irritants of the skin and respiratory system. Recommendations shall be submitted for suitable protective clothing, method of disposal of cleaning utensils and other relevant matters.

The contractor shall also indicate the details and type of filters used in various gas sections, and should also submit the operating experience with such filters.

4.41.1. **SF6 gas monitoring devices and alarm circuits:** Dial type temperature compensated gas density monitoring devices with associated pressure gauge will be provided. The devices shall provide continuous & automatic monitoring of gas density & a separate device shall be provided for each gas compartment so that each compartment can be monitored simultaneously as follows:-

Compartment/ S.N.	Compartments except CB	Circuit Breaker compartments

Compartment/ S.N.	Compartments except CB	Circuit Breaker compartments
1	**"Gas Refill level:** This will be used to annunciate the need for the gas refilling. The contractor shall provide a contact for remote indication.	**'Gas Refill' level :**This will be used to annunciate the need for gas refilling. The contractor shall provide a contact for remote indication.
2	**"SF6 low level" :** This will be used to annunciate the need for urgent gas filling . A contact shall be provided for remote indication	**"SF6 low level" :** This will be used to annunciate the need for urgent gas filling . A contact shall be provided for remote indication
3	**'Zone Trip' level:**	**Breaker Block' level :**
	This is the minimum level at which the manufacturer will guarantee the insulation rating of the assembly.	This is the minimum gas density at which the manufacturer will guarantee the rated fault interrupting capability of the breaker .At this level the breaker block contact shall operate and the closing & tripping circuit shall be
4	**Not Applicable**	**'Zone Trip' level:** This is the minimum level at which the manufacturer will guarantee the insulation rating of the assembly.

The density monitor/pressure switch contacts shall be in accordance with the above requirement.

4.41.2. The contractor should furnish temperature v/s pressure curves for each setting of density monitor along with details of the monitoring device.

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.

4.41.3. **Gas Supply:** The contractor shall include the supply of all SF6 gas necessary for filling & putting into operation the complete switchgear installation being supplied. The empty gas cylinders shall be returnable to the contractor.

5. CIRCUIT BREAKERS

5.1. **General :** SF6 gas insulated metal enclosed circuit breakers shall comply with the latest revisions of IEC- 62271-100 & relevant IEC except to the extent explicitly modified in the specification and shall meet with requirements specified Circuit breakers shall be equipped with the operating mechanism. Circuit breakers shall be of single pressure type. Complete circuit breaker with all necessary items for successful operation shall be supplied. The circuit breakers shall be designed for high speed single and three phase reclosing with an operating sequence and timing as specified.

5.2. **Duty Requirements:** Circuit breaker shall be C2 - M2 class as per IEC 62271-100.

Circuit breaker shall meet the duty requirements for any type of fault or fault location also for line charging and dropping when used on effectively grounded system and perform make and break operations as per the stipulated duty cycles satisfactorily.

5.3. **Pre insertion resister:** 400 kV circuit breakers for line bay (as per the provisions of bid proposal sheet) shall be provided with single step pre insertion closing resistors (wherever the requirement of PIR is explicitly specified so) to limit the switching surges to a value of less than 2.3 p.u for 400kV. The value of the pre- insertion resistor and the duration of pre-insertion time shall be as given in Annexure- 1. The resistor shall have thermal rating for the following duties :

a. **Terminal fault : Close.... 1 Min........ Open...... Close Open 2 min........ Close .... 1 Min........ Open Close Open.**

b. **Reclosing against trapped charges** : Duty same as under (i) above. The first, third and fourth closures are to be on de-energised line while second closing is to be made with lines against trapped charge of 1.2 p.u. of opposite polarity.

c. **Out of phase closing: One** closing operation under phase opposition that is with twice the voltage across the terminals.

No allowance shall be made for heat dissipation of resistor during time interval between successive closing operations. The resistors and resistor supports shall perform all these duties without deterioration. Calculations and test reports of resistors proving thermal rating for duties specified above shall be furnished during detailed engineering. The calculations shall take care of adverse tolerances on resistance values and time settings.

5.4. The circuit breaker shall be capable of:

1. Interrupting the steady and transient magnetizing current shall be as follows:

Voltage Level	**Type of Transformer**	**Rating (in MVA)**
400kV	**400/220kV**	**250 to 630**
220kV	**400/220kV**	**250 to 630**
	220/132kV	**50 to 200**
132kV	**220/132kV**	**50 to 200**
	132/33kV	**10 to 50**

2. Interrupting line/cable charging current as per IEC without re-strikes and without use of opening resistors. The breaker shall be able to interrupt the rated line charging current as per IEC-62271-100 with test voltage immediately before opening equal to the product of U/√3 and 1.4

3. Clearing short line fault (Kilometric faults) with source impedance behind the bus equivalent to symmetrical fault current specified.

4. Breaking 25% the rated fault current at twice the rated voltage under phase opposition condition.

5. The breaker shall satisfactorily withstand the high stresses imposed on them during fault clearing, load rejection and re-energisation of shunt reactor and/or series capacitor compensated lines with trapped charges.

6. Withstanding all dielectric stresses imposed on it in open condition at lock out pressure continuously (i.e. shall be designed for 2 p.u. across the breaker continuously, for validation of which a power frequency withstand test conducted for a duration of at least 15 minutes is acceptable).

7. Circuit breakers shall be able to switch in and out the shunt reactor as detailed below:

Voltage Level	Reactor Rating (in MVAR)	Max. rise of overvoltage (in p.u.)
400kV	**50 to 150**	**2.3**
220kV	**25 to 50**	**2.3**

5.5. **Total Break Time :**The total break time shall not be exceeded under any of the following duties :

a) Test duties T10, T30,T60,T100 (with TRV as per IEC- 62271-100)

b) Short line fault L90, L75 (with TRV as per IEC-62271-100)

The Contractor may please note that total break time of the breaker shall not be exceeded under any duty conditions specified such as with the combined variation of the trip coil voltage (70-110%), pneumatic/hydraulic pressure and SF6 gas pressure etc. While furnishing the proof for the total break time of complete circuit breaker, the contractor may specifically bring out the effect of non-simultaneity between poles and show how it is covered in the total break time.

The values guaranteed shall be supported with the type test reports.

5.6. **Constructional features :**The features and constructional details of breakers shall be in accordance with requirements stated hereunder:

5.6.1. **Contacts:** All making and breaking contacts shall be sealed and free from atmospheric effects. Contacts shall be designed to have adequate thermal and current carrying capacity for the duty specified and to have a life expectancy so that frequent replacement due to excessive burning will not be necessary. Provision shall be made for rapid dissipation of heat generated by the arc on opening.

5.6.2. Any device provided for voltage grading to damp oscillations or, to prevent re-strike prior to the complete interruption of the circuit or to limit over voltage on closing, shall have a life expectancy comparable of that of the breaker as a whole.

5.6.3. Breakers shall be so designed that when operated within their specified rating, the temperature of each part will be limited to values consistent with a long life for the material used. The temperature rise shall not exceed that indicated in IEC-62271-100 under specified ambient conditions.

5.6.4. The gap between the open contacts shall be such that it can withstand at least the rated phase to ground voltage for eight hours at zero pressure above atmospheric level of SF6 gas due to its leakage. The breaker should be able to withstand all dielectric stresses imposed on it in open condition at lockout pressure continuously (i.e. 2 pu. power frequency voltage across the breaker continuously)

5.6.5. In the interrupter assembly there shall be an adsorbing product box to minimize the effect of SF6 decomposition products and moisture. The material used in the construction of the circuit breakers shall be such as to be fully compatible with SF6 gas decomposition products.

5.6.6. Provisions shall be made for attaching an operational analyzer to record travel, speed and making measurement of operating timings etc. after installation at site. The contractor shall supply three set of transducer for each substation covered under the scope.

5.6.7. Circuit Breaker shall be supplied with auxiliary switch having additional 8 NO(normally open) and 8 NC (normally closed) contacts for future use over and above those required for switchgear interlocking and other control and protection function. These spare NO and NC contacts shall be wired upto the local control cubicle.

5.7. **Operating mechanism**

5.7.1. General Requirements :

a) Circuit breaker shall be operated by spring charged mechanism or electro hydraulic mechanism or a combination of these. The mechanism shall be housed in a dust proof cabinet and shall have IP: 42 degree of protection.

b) The operating mechanism shall be strong, rigid, not subject to rebound or to critical adjustments at site and shall be readily accessible for maintenance.

c) The operating mechanism shall be suitable for high speed reclosing and other duties specified. During reclosing the breaker contacts shall close fully and then open. The mechanism shall be anti-pumping and trip free (as per IEC definition) under every method of closing.

d) The mechanism shall be such that the failure of any auxiliary spring will not prevent tripping and will not cause trip or closing operation of the power operating devices.

e) A mechanical indicator shall be provided to show open and close position of the breaker. It shall be located in a position where it will be visible to a man standing on the ground level with the mechanism housing closed. An operation counter shall also be provided.

f) Working parts of the mechanism shall be of corrosion resisting material, bearings which require grease shall be equipped with pressure type grease fittings. Bearing pin, bolts, nuts and other parts shall be adequately pinned or locked to prevent loosening or changing adjustment with repeated operation of the breaker.

g) The contractor shall furnish detailed operation and maintenance manual of the mechanism along with the operation manual for the circuit breaker.

5.7.2. Control

a) The close and trip circuits shall be designed to permit use of momentary-contact switches and push buttons.

b) Each breaker pole shall be provided with two (2) independent tripping circuits and trip coils which may be connected to a different set of protective relays.

c) The breaker shall normally be operated by remote electrical control. Electrical tripping shall be performed by shunt trip coils. However, provisions shall be made for local electrical control. For this purpose a local/remote selector switch and close and trip control switch/push buttons shall be provided in the breaker control cabinet.

d) The trip coil shall be suitable for trip circuit supervision during both open and close position of breaker.

e) Closing coil and associated circuits shall operate correctly at all values of voltage between 85% and 110% of the rated voltage. Shunt trip and associated circuits shall operate correctly under all operating conditions of the circuit breaker upto the rated breaking capacity of the circuit breaker and at all values of supply voltage between 70% and 110% of rated voltage.

f) Densimeter contacts and pressure switch contacts shall be suitable for direct use as permissive in closing and tripping circuits. Separate contacts have to be used for each of tripping and closing circuits. If contacts are not suitably rated and multiplying relays are used then fail safe logic/schemes are to be employed. DC supplies shall be monitored for remote annunciations and operation lockout in case of dc failures.

g) The auxiliary switch of the breaker shall be positively driven by the breaker operating rod.

5.7.3. Spring operated Mechanism

a) Spring operated mechanism shall be complete with motor in accordance with Chapter 2-GTR. Opening spring and closing spring with limit switch for automatic charging and other necessary accessories to make the mechanism a complete operating unit shall also be provided.

b) As long as power is available to the motor, a continuous sequence of the closing and opening operations shall be possible. The motor shall have adequate thermal rating for this duty.

c) After failure of power supply to the motor one close open operation shall be possible with the energy contained in the operating mechanism.

d) Breaker operation shall be independent of the motor which shall be used solely for compressing the closing spring. Facility for manual charging of the closing spring shall also be provided. The motor rating shall be such that it required preferably not more than

90 seconds for full charging of the closing spring.

e) Closing action of circuit breaker shall compress the opening spring ready for tripping.

f) 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 .

g) Provisions shall be made to prevent a closing operation of the breaker when the spring is in the partial charged condition.

h) Mechanical interlocks shall be provided in the operating mechanism to prevent discharging of closing springs when the breaker is in the closed position.

i) The spring operating mechanism shall have adequate energy stored in the operating spring to close and latch the circuit breaker against the rated making current and also to provide the required energy for the tripping mechanism in case the tripping energy is derived from the operating mechanism.

5.7.4. Hydraulically Operated Mechanism :

a) Hydraulically operated mechanism shall comprise of operating unit with power cylinder, control valves, high and low pressure reservoir, motor etc.

b) The hydraulic oil used shall be fully compatible for the temperature range to be encountered during operation.

c) 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.

d) The mechanism shall be suitable for at-least two close open operations after failure of AC supply to the motor starting at pressure equal to the lowest pressure of auto reclose duty plus pressure drop for one close open operation.

e) 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 make up.

f) 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.

g) All hydraulic joints shall have no oil leakage under the site conditions and joints shall be tested at factory against oil leakage.

5.8. **Controlled Switching Device (CSD):**

5.8.1. 400KV Circuit Breaker shall be equipped with controlled switching device with consequent optimization of switching behavior, when used in:

1. Switching of transformer
2. Switching of shunt reactor

5.8.2. The CSD shall be provided in 400kV Circuit breakers for controlling transformers and reactors (ie for breakers of switchable line reactor and in Main& Tie circuit breakers of Transformers, Transmission lines with non-switchable line reactors and Bus reactors). The requirement of CSD shall be explicitly specified in price schedule

5.8.3. The controlled switching device shall

a) be designed to operate correctly and satisfactorily with the excursion of auxiliary A/C & DC voltages and frequency as specified in Chapter 2 - GTR.
b) meet the requirements of IEC-61000-4 16 class IV regarding HF disturbance test and fast transient test shall be as per IEC-61000 – 4-4 level IV and insulation test as per 60255 – 5.
c) have functions for switching ON & OFF the circuit breakers.
d) 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 the switching the circuit breaker and issue command to circuit breaker to operate.
e) 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 provided by the contractor. The accuracy of the operating time estimation by the controller shall be better than + 0.5 ms.
f) have communication port to facilitate online communication of the control switching device with SCADA directly on 61850 or through gateway which shall be under present scope.
g) 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 along with PC for this purpose shall be supplied by the contractor.
h) have self-monitoring facility.
i) be suitable for current input of 1 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.
j) have time setting resolution of 0.1 ms or better.
k) shall have sufficient number of output/input potential free contacts for connecting the monitoring equipment and annunciation system available in the control room. Necessary details shall be worked out during engineering the scheme.

5.8.4. The CSD shall also record and monitor the switching operations and make adjustments to the switching instants to optimize the switching behavior as necessary. It shall provide self-diagnostic facilities, signaling of alarms and enable downloading of data captured from the switching events.

5.8.5. The provision for bypassing the Controlled switching device shall be provided through SCADA. 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.

5.9. The technical parameters of Circuit breakers are as per Annexure -1

5.10. **Additional data to be furnished during detailed engineering :**

a) Drawing showing contacts in close, arc initiation, full arcing, arc extinction and open position.

b) Data on capabilities of circuit breakers in terms of time and number of operations at duties ranging from 100 fault currents to load currents of the lowest possible value without requiring any maintenance or checks.

c) Curves supported by test data indicating the opening time under close open operation with combined variation of trip coil voltage and hydraulic pressure.

5.11. **Tests :**

5.11.1. **Type Tests**:

i. In accordance with the requirements stipulated under Section GTR the circuit breaker along with its operating mechanism shall conform to the type tests as per IEC-62271-100.

ii. The type test report of Electromagnetic Compatibility Test (EMC) of CSD shall be submitted for approval

5.11.2. Routine Tests:

Routine tests as per IEC: 62271-100 shall be performed on all circuit breakers.

In addition to the mechanical and electrical tests specified by IEC, the following shall also be performed.

i. Speed curves for each breaker shall be obtained with the help of a suitable operation analyzer to determine the breaker contact movement during opening, closing, auto-reclosing and trip free operation under normal as well as limiting operating conditions (control voltage, pneumatic pressure etc.). The tests shall show the speed of contacts directly at various stages of operation, travel of contacts, opening time, closing time, shortest time between separation and meeting of contacts at break make operation etc. This test shall also be performed at site for which the necessary operation analyzer along with necessary transducers, cables, console etc. shall be provided.

ii. Functional tests are to be carried out on circuit breaker along with Control Switching device (CSD).

iii. DCRM (Dynamic Contact Resistance Measurement) to be carried out for all CBs during routine test.

6. DISCONNECTORS (ISOLATORS)

6.1. Disconnectors shall be three-pole group operated or Single-pole individual operated (as per single line diagram of the substation) and shall be installed in the switchgear to provide electrical isolation. The disconnectors shall conform to IEC- 62271-102 and shall have the ratings as specified in BPS.

6.2. **Construction & Design**.

6.2.1. The disconnectors shall be operated by electric motor suitable for use on DC system and shall be equipped with a manual operating mechanism for emergency use. The motor shall be protected against over current and short circuit.

6.2.2. Disconnectors shall be suitable to switch the bus charging currents during their opening and closing and shall confirm to all three test duties viz TD1,TD2 and TD3 as per Annexure-F of IEC: 62271- 102.They shall also be able to make and break rated bus transfer current at rated bus transfer voltage which appears during transfer between bus bars in accordance with Annexure-B of IEC: 62271-102. The contact shielding shall also be designed to prevent restrikes and high local stresses caused by transient recovery voltages when these currents are interrupted.

6.2.3. The disconnecting switches shall be arranged in such a way that all the three phases operate simultaneously. All the parts of the operating mechanism shall be able to withstand starting torque of the motor mechanism without damage until the motor overload protection operates.

6.2.4. It shall be possible to operate the disconnecting switches manually by cranks or hand wheels. The contacts shall be both mechanically and electrically disconnected during the manual operation.

6.2.5. The operating mechanisms shall be complete with all necessary linkages, clamps, couplings, operating rods, support brackets and grounding devices. All the bearings shall be permanently lubricated or shall be of such a type that no lubrication or maintenance is required.

6.2.6. The opening and closing of the disconnectors shall be achieved by either local or remote control. The local operation shall be by means of a two-position control switch located in the Local Control Cabinet (LCC) .

6.2.7. Remote control of the disconnectors from the control room/SAS shall be made by means of remote/ local transfer switch.

6.2.8. The disconnector operations shall be inter-locked electrically with the associated circuit breakers in such a way that the disconnector control is inoperative if the circuit breaker is closed.

6.2.9. Each disconnector shall be supplied with auxiliary switch having additional 4 NO (Normally Open) and 4 NC (Normally Closed) contacts for future use over and above those required for switchgear interlocking and automation purposes. These spare NO and NC contacts shall be wired up to the local control cabinet.

6.2.10. The signaling of the closed position of the disconnector shall not take place unless it is certain that the movable contacts will reach a position in which the rated normal current, peak withstand current and short-time withstand current can be carried safely.

6.2.11. The signaling of the open position of the disconnector shall not take place unless the movable contacts have reached such a position that the clearance between the contacts is at least 80 percent of the rated isolating distance.

6.2.12. The disconnectors and safety grounding switches shall have a mechanical and electrical inter-locks to prevent closing of the grounding switches when isolator switches are in the closed position and to prevent closing of the disconnectors when the grounding switch is in the closed position. Integrally mounted lock when provided shall be equipped with a unique key for such three phase group. Master key is not permitted.

6.2.13. The local control of the Isolator and high-speed grounding switches from the Local Control Cabinet (LCC) should be achieved from the individual control switches with the remote/local transfer switch set to local.

6.2.14. All electrical sequence interlocks will apply in both remote and local control modes.

6.2.15. Each disconnector shall have a clearly identifiable local, positively driven mechanical position indicator, together with position indicator on the local control cubicle (LCC) and provisions for taking the signals to the control room. The details of the inscriptions and colouring for the indicator are given as under :

	INSCRIPTION	COLOUR
Open position	OPEN	GREEN
Closed position	CLOSED	RED

6.2.16. All the disconnecting switches shall have arrangement allowing easy visual inspection of the travel of the switch contacts in both open and close positions, from the outside of the enclosure.

6.2.17. The disconnecting switches shall be provided with rating plates and shall be easily accessible.

6.2.18. The mechanical endurance class shall be M2 as per IEC for 400kV and 220kV and it shall be M1 class for 132kV disconnectors

6.2.19. Mechanical position indication shall be provided locally at each disconnector and Electrical indication at each Local Control Cabinet (LCC) / SAS.

6.3. The technical parameters of disconnectors are as per **Annexure-2**

7. SAFETY GROUNDING SWITCHES

7.1. Safety grounding switches shall be three-pole group operated or single-pole individual operated (as per single line diagram of the substation). It shall be operated by DC electric motor and shall be equipped with a manual operating mechanism for emergency use. The motor shall be protected against over-current and short circuit.

7.2. Each safety grounding switch shall be electrically interlocked with its associated disconnectors and circuit breaker such that it can only be closed if both the circuit breaker and disconnectors are in open position. Safety grounding switch shall also be mechanically key interlocked with its associated disconnectors.

7.3. Each safety grounding switch shall have clearly identifiable local positive driven mechanical indicator together with position indicator on the Local Control Cabinet (LCC) and provision for taking the signal to Control room.

7.4. The details of the inscription and colouring for the indicator are given as under :

INSCRIPTION	COLOUR

Open position	OPEN	GREEN
Closed position	CLOSED	RED

7.5. Interlocks shall be provided so that manual operation of the switches or insertion of the manual operating device will disable the electrical control circuits.

7.6. Each ground switch shall be fitted with auxiliary switches having 4 NO (Normally Open) and 4 NC (Normally Closed) contacts for use by others over and above those required for local interlocking and position indication purposes.

7.7. Provision shall be made for padlocking / suitable locking arrangement for the ground switches in either the open or closed position.

7.8. All portions of the grounding switch and operating mechanism required for grounding shall be connected together utilizing flexible copper conductors having a minimum cross-sectional area of 100 sq. mm.

7.9. The main grounding connections on each grounding switch shall be rated to carry the full short circuit current for 1 sec. and shall be equipped with a silver- plated terminal connector suitable for steel strap of adequate rating for connection to the grounding grid.

7.10. The safety grounding switches shall conform to the requirements of IEC- 62271- 102 and shall have electrical endurance class: E0 & shall have mechanical endurance class M2 for 400 kV & M1 for 220/132 kV voltage level.

7.11. Combined Disconnectors & Safety grounding switch arrangement shall also be acceptable.

7.12. Mechanical position indication shall be provided locally at each switch and Electrical indication at each Local Control Cabinet (LCC) / SAS.

7.13. Continuous current rating of the grounding switches (not less than 100A) shall be specified by the manufacturer, which can be safely injected for Bay/ Bus equipment testing.

8. HIGH SPEED MAKE PROOF GROUNDING SWITCHES:

8.1. Grounding switches located at the beginning of the line feeder bay modules shall be of the high speed, make proof type and will be used to discharge the respective charging currents, trapped charge in addition to their safety grounding function. These grounding switches shall be capable of interrupting the inductive and capacitive currents and to withstand the associated TRV. These shall confirm to class B and electrical endurance class E1 as per annexure- C of IEC : 62271-102

8.2. High Speed Grounding switches shall be provided with individual/three pole operating mechanism suitable for operation from DC.

8.3. The switches shall be fitted with a stored energy closing system to provide fault making capacity.

8.4. The short circuit making current rating of each ground switch shall be at least equal to its peak withstand current rating as stated in clause 1.4 above. The switches shall have inductive/ capacitive current switching capacity as per IEC-62271-102.

8.5. Each high speed make proof grounding switch shall have clearly identifiable local positive driven mechanical indicator together with position indicator on the Local Control Cabinet (LCC) and provision for taking the signal to Control Room/SAS.

8.6. The details of the inscription and colouring for the indicator shall be as under:-

	INSCRIPTION	COLOUR
Open position	OPEN	GREEN
Closed position	CLOSED	RED

8.7. High speed ground switch operation should be possible locally from Local Control Cabinet (LCC)

8.8. These high speed grounding switches shall be electrically interlocked with their associated circuit breakers and disconnectors so that the grounding switches cannot be closed if disconnectors are closed. Interlocks shall be provided so that the insertion of the manual operating devices will disable the electrical control circuits.

8.9. Each high speed ground switch shall be fitted with auxiliary switches having 4 NO (Normally Open) and 4 NC (Normally Closed) contacts for use by others, over and above these required for local interlocking and position indication. All contacts shall be wired to terminal blocks in the Local Control Cabinet. Provision shall be made for padlocking the ground switches in their open or closed position.

8.10. All portion of the grounding switches and operating mechanism required for connection to ground shall be connected together utilizing copper conductor having minimum cross-sectional area of 100 sq. mm.

8.11. The main grounding connection on each grounding switch shall be rated to carry the peak withstand current rating of the switch for 1 sec. and shall be equipped with a silver plated terminal connector suitable for steel strap of adequate design for connection to the grounding grid.

8.12. The high speed make proof grounding switches shall confirm to the requirements of IEC-62271-102.

8.13. Continuous current rating of the High speed grounding switches (not less than 100A) shall be specified by the manufacturer, which can be safely injected for Bay/ Bus equipment testing.

9. INSTRUMENT TRANSFORMERS

9.1. **Current Transformers**

The current transformers and accessories shall conform to IEC: 60044-1 and other relevant standards except to the extent explicitly modified in the specification.

9.1.1. **Ratios and Characteristics: The** CT core distribution for various voltage levels shall be as per Table 3A, 3B, 3C & 3D. Further the numbers of cores, rating, ratios, accuracy class, etc. for the individual current transformers secondary cores shall be in accordance with above table.

Where multi-ratio current transformers are required the various ratios shall be obtained by changing the effective number of turns on the secondary winding.

9.1.2. **Rating and Diagram Plates: Rating** and diagram plates shall be as specified in the IEC specification incorporating the year of manufacture. The rated extended current rating voltage and rated thermal current shall also be marked on the name plate.

The diagram plates shall show the terminal markings and the relative physical arrangement of the current transformer cores with respect to the primary terminals (P1 & P2).

The position of each primary terminal in the current transformer SF6 gas section shall be clearly marked by two plates fixed to the enclosure at each end of the current transformer.

9.1.3. **Constructional Details**:

a) The current transformers incorporated into the GIS will be used for protective relaying and metering purposes and shall be of metal- enclosed type.

b) Each current transformer shall be equipped with a secondary terminal box with terminals for the secondary circuits, which are connected to the Local Control Cubicle. The star/ delta configuration and the inter connection to the line protection panels will be done at the CT terminal block located in the local control cubicle.

c) Current transformers guaranteed burdens and accuracy class are to be intended as simultaneous for all cores.

d) The rated extended currents for and 420 kV class Current transformers shall be Current transformers shall be as given below:

Tap Ratio	**400kV, 4000A** **Rated extended currents in % of rated current**
500/1	**200**
1000/1	…..
2000/1	180
4000/1	120

The secondary winding shall be rated for 2A continuously.

e) For 245/145 kV class CTs, the rated extended primary current shall be 120% (or 150% if applicable) on all cores of the CTs as specified in the Chapter 1- PSR.

f) For 420/245/145 kV current transformer, characteristics shall be such as to provide satisfactory performance of burdens ranging from 25% to 100% of rated burden over a range of 5% to 120%(or specified rated extended current whichever is higher) of rated current in case of metering CTs and up to the accuracy limit factor/knee point voltage in case of relaying CTs.

g) The instrument security factor at all ratios shall be less than five (5) for metering core. If any auxiliary CTs/reactor are used in the current transformers then all parameters specified shall have to be met treating auxiliary CTs as an integral part of the current transformer. The auxiliary CTs/reactor shall preferably built in construction of the CTs.

h) The wiring diagram, for the interconnections of the three single phase CTs shall be provided inside the Secondary terminal box.

i) The current transformers shall be suitable for high speed auto-reclosing.

j) Provisions shall be made for primary injection testing either within CT or outside.

k) All the current transformers shall have effective electromagnetic shields to protect against high frequency transients. Electromagnetic shields to be provided against high frequency transients typically 1-30 MHz.

9.2. **VOLTAGE TRANSFORMERS**

The voltage transformers shall conform to IEC- 60044-2 and other relevant standards except to the extent explicitly modified in the specification.

Voltage transformers shall be of the electromagnetic type with SF6 gas insulation. The earth end of the high voltage winding and the ends of the secondary winding shall be brought out in the terminal box.

9.2.1. **Ratios and Characteristics**: The rating, ratio, accuracy class, connection etc. for the voltage transformers shall be in accordance with annexure -4 & Table 4A and Table 4B

9.2.2. **Rating and diagram plates** :Rating and diagram plate shall be provided complying with the requirements of the IEC specification incorporating the year of manufacture and including turns ratio, voltage ratio, burden, connection diagram etc.

9.2.3. **Secondary Terminals, Earthing**

The beginning and end of each secondary winding shall be wired to suitable terminals accommodated in a terminal box mounted directly on the voltage transformer section of the SF6 switchgear.

All terminals shall be stamped or otherwise marked to correspond with the marking on the diagram plate. Provision shall be made for earthing of the secondary windings inside the terminal box.

9.2.4. The transformer shall be able to sustain full line to line voltage without saturation of transformer.

9.2.5. Constructional Details of Voltage Transformers:

a) The voltage transformers shall be located as a separate bay module and will be connected phase to ground and shall be used for protection, metering and synchronization.

b) The voltage transformers shall be of inductive type, nonresistant and shall be contained in their own-SF6 compartment, separated from other parts of installation. The voltage transformers shall be effectively shielded against high frequency electromagnetic transients. The supplier shall ensure that there is no risk of Ferro resonance due to the capacitance of the GIS.

c) The voltage transformers shall have three secondary windings.

d) Voltage transformers secondary shall be protected by Miniature Circuit breakers (MCBs) with monitoring contacts for all the windings. The secondary terminals of the VT's shall be terminated to preferably stud type non-disconnecting terminal blocks in the secondary boxes via the fuse.

e) The voltage transformer should be thermally and dielectrically safe when the secondary terminals are loaded with the guaranteed thermal burdens.

f) The accuracy of 0.2 on secondary III should be maintained throughout the entire burden range up to 50 VA on all the three windings without any adjustments during operation.

g) The diagram for the interconnection of the VTs shall be provided inside secondary terminal box.

9.3. **Tests:**

Current and voltage transformers shall conform to type tests and shall be subjected to routine test in accordance with IEC.

10. SURGE ARRESTORS

10.1. The surge arrestors shall confirm in general to latest IEC –60099-4.

10.2. **Insulation co-ordination and selection of surge arrestor**: The contractor shall be fully responsible for complete insulation co-ordination of switchyard including GIS. Contractor shall carry out detailed studies and design calculations to evolve the required parameters locations, energy capability etc. of surge arrestors such that adequate protective margin is available between peak impulse, surge and power frequency discharge voltages and BIL of the protected requirement. The locations of surge arrestors shown in single line diagram is indicative only. If the contractor feels that at some more locations the surge arrestors are required to be provided the same should also be deemed included in the offer.

The contractor shall perform all necessary studies and the report shall detail the limits of all equipment parameters which could affect the insulation co-ordination. The report shall also detail the characteristics of the surge arrestor and shall demonstrate that the selected arrestor's protective and withstand levels, discharge and coordinating currents and arrestor ratings and comply with the requirement of this specification.

The contractor shall also consider in the studies the open circuit breaker condition, fast transients generated by slow operation of disconnecting switches. The study report and design calculations shall be submitted for Owner's approval.

10.3. **Duty requirements of GIS Surge Arrestor**

10.3.1. The surge arrester shall be of heavy duty station class and gapless (Metal oxide) type without any series or shunt gaps.

10.3.2. The surge arresters shall be capable of discharging over-voltages occurring during switching of unloaded transformers, reactors and long lines.

10.3.3. Surge arresters for the 400 kV network shall be capable of discharging of severe re-energisation switching surges on a 400 kV, 450 Km long line with surge impedance of 300 ohms and capacitance of 12 nF/Km and over voltage factor of 2.3 p.u at the arrestor terminals.

400 kV class arrester shall be capable of discharging energy equivalent to class 4 of IEC for a 400 kV system on two successive operation followed immediately by 50 HZ

energisation with a sequential voltage profile as specified below:

650 kVp for 3 peaks

575 kVp for 0.1 Sec.

550 kVp for 1 Sec.

475 kVp for 10 Secs.

10.3.4. 245 & 145kV class arrester shall be capable of discharging energy equivalent to class 3 of IEC for 245 kV & 145 kV system respectively on two successive operations.

10.3.5. The reference current of the arresters shall be high enough to eliminate the influence of grading and stray capacitance on the measured reference voltage.

10.3.6. The surge arresters are being provided to protect the followings whose insulation levels are indicated in the table given below:-

Equipment to be protected	400kV system		220KV system	132KV system
	Lightning impulse (kVp)	Switching surge (kVp)	Lightning impulse (kVp)	Lightning impulse (kVp)
Power Transformer	$\pm$ 1300	$\pm$ 1050	$\pm$ 950	$\pm$ 550
Instrument Transformer	$\pm$ 1425	$\pm$ 1050	$\pm$ 1050	$\pm$ 650
Reactor	$\pm$ 1300	$\pm$ 1050	-	-
CB/Isolator Phase to ground	$\pm$1425	$\pm$ 1050	$\pm$ 1050	$\pm$ 650
CB/Isolator Across open contacts	$\pm$ 1425 (-/+240)	$\pm$ 900 (-/+345)	$\pm$ 1200	$\pm$ 750

10.3.8. Constructional Features

The nonlinear blocks shall be of sintered/infered metal oxide material. These shall be provided in such a way as to obtain robust construction, with excellent mechanical and electrical properties even after repeated operations.

The arrestor enclosure shall be vertically or horizontally mounted to suit the layout of the switchgear as suggested by the supplier and each arrestor shall be fitted with a Online continuous resistive leakage current monitoring system. The system shall be provided with an interface to integrate with the substation automation system.

The main grounding connection from the surge arrestor to the earth shall be provided by the contractor. The size of the connecting conductor shall be such that all the energy is dissipated to the ground without getting overheated.

10.4. **Tests**

10.4.1. In accordance with the requirements stipulated, the surge arrestors shall conform to type tests and shall be subjected to routine and acceptance tests in accordance with IEC document.

10.4.2. Each metal oxide block shall be tested for the guaranteed specific energy capability in addition to the routine/acceptance test as per IEC-60099.

10.4.3. Test on Surge Monitors: The Surge monitors shall also be connected in series with the test specimens during residual voltage and current impulse withstand tests to verify efficacy of the same. Additional routine/functional tests with one 100A and 10 kA current impulse, (8/20 micro sec.) shall also be performed on the surge monitor.

10.5. **Technical Parameters** : Technical parameters are as per annexure 5;

11. OUTDOOR BUSHINGS :

Outdoor bushings, for the connection of conventional external conductors to the SF6 metal enclosed switchgear, shall be provided where specified and shall conform to the requirements given in GTR.

The dimensional and clearance requirements for the metal enclosure will be the responsibility of the manufacturer and their dimensions must be coordinated with the switchgear.

Bushings shall generally be in accordance with the requirements of IEC -60137.

11.1. Insulation levels and Creepage distances: All bushings shall have an impulse and power frequency withstand level that is greater than or equal to the levels specified for GIS.

The creepage distance over the external surface of outdoor bushings shall not be less than 25 mm/kV and in highly polluted area it shall not be less than 31mm/kV (as per section-Project).

11.2. **Bushing types and fitting**: The details of bushing shall be as follows

SF6 to air Bushing shall be of Polymer / composite type and shall be robust and designed for adequate cantilever strength to meet the requirement of seismic condition, substation layout. The electrical and mechanical characteristics of bushings shall be in accordance with IEC: 60137. All details of the bushing shall be submitted for approval and design review.

Polymer / composite insulator shall be seamless sheath of a silicone rubber compound. The housing & weather sheds should have silicon content of minimum 30% by weight. It should protect the bushing against environmental influences, external pollution and humidity. The hollow silicone composite insulators shall comply with the requirements of the IEC publications IEC 61462 and the relevant parts of IEC 62217. The design of the composite insulators shall be tested and verified according to IEC 61462 (Type & Routine test)

11.3. **Mechanical forces on bushing terminals:** Outdoor bushings must be capable of withstanding cantilever forces due to weight of bus duct (GIB) on one side & AIS conductor/Al tube on the other side and short circuit forces. Design calculations in support of the cantilever strength chosen shall be submitted for owners review and approval.

11.4. Type test reports as per applicable IEC including radio interference voltage (RIV) test shall be submitted in line with the requirement as specified in Chapter 2-GTR for approval.

11.5. The technical parameters of Bushing are as per Annexure -6

12. SF6 GIS TO XLPE CABLE TERMINATION

12.1. The underground cables shall be connected to GIS by the interfacing of XLPE cable sealing end to GIS Cable termination enclosure.

12.2. The SF6 GIS to XLPE cable termination shall conform to IEC-62271-209.

12.3. The rating of XLPE cables for different voltages are specified in the Chapter 1-PSR.

12.4. Cable termination kit shall be in the scope of the contract. The ducts and the casing shall be suitable for the requirements for which it is designed. This interface section shall be designed in a manner which will allow ease of operation and maintenance.

12.5. The provision shall be made for a removable link. The gap created when the link is removed should have sufficient electric strength to withstand the switchgear high voltage site tests. The contractor may suggest alternative arrangements to meet these requirements. The corona rings/stress shields for the control of electrical field in the vicinity of the isolation gap shall be provided by the GIS manufacturer.

12.6. All supporting structures for the SF6 bus-duct connections between the XLPE cable sealing ends and the GIS shall be the scope of the contract. The supplier may specify alternative connecting & supporting arrangements for approval of the purchaser.

12.7. The opening for access shall be provided in each phase terminal enclosures as necessary to permit removal of connectors to isolate the XLPE cables to allow carrying out the insulation tests. The general arrangement drawing of interconnecting bus-duct from GIS bay module to XLPE cable termination end shall also be submitted.

12.8. Type test reports of radio interference voltage (RIV) level shall be submitted for approval

13. TRANSFORMER / REACTOR TERMINATION MODULE (Applicable for SF6 to Oil Bushings)

13.1.1. The transformer / reactor termination module enables a direct transition from the SF6 gas insulation to the bushing of an oil-insulated transformer / reactor. For this purpose, the transformer/reactor bushing must be oil-tight, gas-tight and pressure resistant. Any temperature related movement and irregular setting of the switchgear's or transformer's/reactor's foundations are absorbed by the expansion fitting.

13.1.2. The oil filled transformers and reactors are as shown in the substation SLD. The oil to air bushings of the transformers and reactors shall be supplied by the respective supplier's and the same shall be connected to the SF6 ducts thru air to SF6 bushings to be provided under present scope.

13.1.3. Terminal connection arrangement to connect GIS duct to bushing and duct mounting arrangement details shall be submitted during detailed engineering for Employer's approval and for co-ordination with transformer and reactor supplier. Any modification suggested by autotransformer and reactor supplier shall have to be carried out by the supplier to facilitate proper connection with the bushings of the autotransformer and reactors.

13.1.4. In case of single phase transformers are being installed in the substation, HV &IV

auxiliary bus for the transformer bank for connecting spare unit shall be formed inside the GIS hall as per the SLD furnished and as specified in Chapter 1-PSR .

13.1.5. In case of single phase reactors are being installed in the substation auxiliary bus of rated voltage for the reactor bank for connecting spare unit shall be formed inside the GIS hall as per the SLD furnished and as specified in Chapter 1-PSR.

14. LOCAL CONTROL CUBICLE (LCC)

14.1. Functions

14.1.1. Each circuit-breaker bay shall be provided with a local control cubicle containing local control switches and a mimic diagram for the operation and semaphore for status indication of the circuit-breaker and all associated isolators and earth switches together with selector switches to prevent local and remote and supervisory controls being in operation simultaneously

14.1.2. Status indications in the LCC shall be semaphore type or LED type.

14.1.3. Closing of the circuit- breaker from the local control unit shall only be available when the breaker is isolated for maintenance purposes. Circuit-breaker control position selector, operating control switch and electrical emergency trip push button shall be installed in the Local Control Cubicle. Circuit-breaker control from this position will be used under maintenance and emergency conditions only. The emergency trip push buttons shall be properly shrouded.

14.1.4. If Disconnector or earth switch is not in the fully open or closed position a "Control Circuit Faulty" alarm shall be initiated, and electrical operation shall be blocked.

14.1.5. 20% spare terminals shall be provided in each LCC apart from terminals provided for the termination and interconnection of all cabling associated with remote and supervisory control, alarms, indications, protection and main power supply etc .

14.1.6. Where plugs and sockets connect control cabling between the local control cubicle and the switchgear these shall not be interchanged.

14.1.7. Hydraulic/pneumatic and SF6 auxiliary equipment necessary for the correct functioning of the circuit breaker, isolators and earth switches shall be located in a separate cubicle compartment.

14.1.8. LCC shall be suitable for remote operation from substation automation system (SAS). Each gas tight compartment shall be monitored individually per phase basis through SAS

14.2. Constructional features

14.2.1. Local Control cubicle shall be either mounted on the GIS with front access or free standing, floor mounting type. It shall comprise structural frames completely enclosed with specially selected smooth finished, cold rolled sheet steel of thickness not less than 3 mm for weight bearing members of the panels such as base frame, front sheet and door frames, and 2.0mm for sides, door, top and bottom portions. There shall be sufficient reinforcement to provide level transportation and installation.

14.2.2. Access to all compartments shall be provided by doors. All fastenings shall be integral with the panel or door and provision made for locking. Cubicles shall be well ventilated through vermin-proof louvers having anti insect screen. All doors shall be gasketed all around with suitably profiled Neoprene/EPDM gaskets conforming with provision of IS 11149. However, XLPE gaskets can also be used for fixing protective glass doors.

14.2.3. Each LCC panel should have its own separate AC supply source feed from the ACDB. The DC supply shall be from respective relay & protection panel power, control, interlocking, signaling. Each panel shall be provided with necessary arrangements for receiving, distributing and isolating of DC and AC supplies for various control, signaling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with Fuses. All fuses shall be HRC cartridge type conforming to IS: 13703 mounted on plug-in type fuse bases. The short time fuse rating of Fuses shall be not less than 9 KA. Fuse carrier base shall have imprints of the fuse 'rating' and 'voltage'.

14.2.4. Each LCC Panel shall be provided with the following

1. **Plug Point**: 230V, Single phase 50Hz, AC socket with switch suitable to accept 5 Amps and 15 Amps pin round standard plug, shall be provided in the interior of each cubicle with ON-OFF switch.
2. **Interior Lighting**: Each panel shall be provided with a fluorescent lighting fixture rated for 230 Volts, single phase, 50 Hz supply for the interior illumination of the panel controlled by the respective panel door switch. Adequate lighting shall also be provided for the corridor in Duplex panels.
3. **Space Heater**: Each panel shall be provided with a thermostatically connected space heater rated for 230V, single phase, 50 Hz AC supply for the internal heating of the panel to prevent condensation of moisture. The fittings shall be complete with switch unit

14.2.5. Operating mechanisms, auxiliary switches and associated relays, control switches, control cable terminations, and other ancillary equipment shall be accommodated in sheet steel vermin proof cubicles.

14.2.6. Local control cubicles shall be provided to be free standing and shall be equipped with anti-condensation heaters. A suitable humidity stat and thermostat shall be included in the heater circuit.

14.2.7. The interior of each cubicle shall be finished with a semi gloss white surface. An interior lamp suitable for the local LVAC supply, controlled by a door-operating switch, shall be fitted at the top of each panel.

14.2.8. The arrangement of equipment within cubicles shall be such that access for maintenance or removal of any item shall be possible with the minimum disturbance of associated apparatus. All the control switches shall be internal i.e. installed behind a lockable glass door.

14.2.9. An interlocking scheme shall be provided that takes into account the following basic requirements.

- To safeguard maintenance personnel who may be working on one section of the equipment with other sections live.
- prevent incorrect switching sequences that could lead to a hazardous situation to plant, equipment and personnel.

14.2.10. Electrical bolt interlocks shall be energized only when the operating handle of the mechanism is brought to the working position. Visible indication shall be provided to show whether the mechanism is locked or free. Means, normally padlocked, shall be provided whereby the bolt can be operated in the emergency of a failure of interlock supplies.

14.2.11. Where key interlocking is employed tripping of the circuit breaker shall not occur if any attempt is made to remove the trapped key from the mechanism. Any local emergency-tripping device shall be kept separate and distinct from the key interlocking.

14.2.12. Disconnecting switches shall be so interlocked that they cannot be operated unless the associated circuit-breaker is open except that where double bus bar arrangements are specified, on-load transfer of feeder circuits from one bus bar to another shall be made possible by interlocks which ensure that the associated bus coupler and its isolators are closed.

14.2.13. Bus coupler circuit breaker shall be interlocked so that it shall not be possible to open a bus coupler circuit breaker while on load change over on that side of the breaker is in progress.

14.2.14. All isolating devices shall be interlocked with associated circuit-breakers and isolators in the same station so that it shall not be possible to make or break current on an isolating device unless a parallel circuit in that station is already closed.

15. GIS BUILDING

15.1. The buildings shall house each voltage class Gas Insulated Switchgear (GIS) separately and other associated equipment inside in each of the GIS buildings. GIS building(s) shall be constructed for the specified number of bays/diameters as per Chapter 1-PSR.

15.2. The contractor shall submit the design & construction proposal of the building along with necessary information, data, and drawings during the detailed engineering according to the complete requirements.

15.3. The area for GIS hall(s) is indicated in the enclosed General Arrangement drawing. The area given is for reference only and may vary according to requirement of the equipment to be installed inside. The contractor shall finalize the dimensions according to the equipment offered by them providing enough space & access for erection, operation and maintenance.

15.4. The contractor shall place their panels i.e. Bay level units, bay mimic, relay and protection panels, RTCC panels etc. in a separate room in the GIS building or control room building as applicable. The size of the room shall be such that all the panels for the future bays/ diameters as per clause 15.1 shall be accommodated in the above room. The panel room shall be air-conditioned. Further, the temperature of the room shall be monitored through substation automation system by providing necessary temperature transducers.

16. ELECTRIC OVERHEAD CRANE :

16.1. One EOT Crane each for GIS hall of suitable capacity shall be provided for erection & maintenance of largest GIS component/assembly. The crane shall consist of all special requirements for erection & maintenance of GIS equipment.

16.2. The capacity of the crane shall be sized to lift the heaviest GIS switchgear component crane.

16.3. The Crane shall be used for the erection and maintenance of the GIS switchgear component and all plant installed in the GIS switchgear room .On completion of erection of the switchgear, the Contractor shall completely service the crane before the Taking Over Certificate is issued.

16.4. Crane hook approaches shall be of the minimum possible dimensions to ensure maximum coverage of the plant area.

16.5. The crane(s) shall be capable of lifting and accurately positioning all loads ranging from full crane rated capacity to at least 10% rated capacity.

16.6. The crane shall have minimum speeds under full load of:

Speed

(a) Hoisting 2 meters/minute

(b) Cross Travel 10 meters/minute

(c) Long Travel 20 meters/minute

(d) Creep speed shall be of 25% of operating speed

16.7. The electric overhead cranes shall be provided with walkways, platforms. Guard hand rails shall be provided along the bridge rails and on the crab of EOT crane to facilitate cleaning/maintenance of the crane and to give access to the GIS room high bay lighting and ventilation duct and grilles.

16.8. The platform and walkways shall be designed to support any weight to be imposed upon them during crane overhaul.

16.9. An access platform shall be provided together with a guarded ladder on the crane to allow access to the bridge rails.

16.10. The crane shall be possible to be operated through the cable, through the pendant control and which shall be easily accessible from the floor of GIS building and through remote control device.

16.11. Contractor shall submit the capacity calculation of crane for GIS hall considering a factor of safety of 5.

a) The crane for 400kV GIS hall shall have capacity of minimum 10T safe working load & minimum height of crane have shall be 9.0 meters or as per actual requirement whichever is higher.

b) The crane for 220kV GIS/132kV GIS shall have capacity of minimum 6T safe working load & minimum height of crane have shall be 8.0 meters or as per actual requirement whichever is higher.

16.12. In case the GIS hall is to be extended, the scope of work also involves extension of EOT crane girders to facilitate movement of EOT crane in the extended portion of GIS hall.

16.13. The following tests shall be carried out in EOT Crane

1. The crane shall be tested at manufacturer work under full load and 25 percent overload of hoisting and cross transverse motions as a routine test.

2. Further the following tests may be done at site after installation of the crane at site
   a. Check althea accessories for proper function
   b. No load test
   c. Load test as per site conditions

17. VENTILATION SYSTEM FOR GIS HALL

17.1. Each GIS Hall shall have an independent ventilation system. Each Ventilation system shall consist of two 100% capacity systems, one operating and one stand-by.

17.2. To ensure that the air being supplied to the GIS hall is free from dust particles, a minimum two stage dust filtration process shall be supplied. This shall consist of at least the following:

1. Pre Filters: To remove dust particles down to 10 micron in size with at least 95% efficiency.
2. Fine Filters: To remove dust particles down to 5 microns in size with at least 99% efficiency.

All the filters shall be panel type. Easy access should be available to the filters for replacement/cleaning.

The ventilation of the GIS hall shall be of a positive pressure type with minimum 4 air changes per hour. The pressure inside the GIS hall shall be maintained 5 mm of water above the atmospheric pressure. Fresh outdoor air shall be filtered before being blown into the GIS hall by the air fans to avoid dust accumulation on components present in the GIS hall. GIS hall shall be provided with motorized exhaust dampers with local control.

17.3. In case of extension of GIS hall is covered under the present contract, separate ventilation system shall be provided meeting the functional requirement as specified above and the same shall be integrated with existing ventilation system.

18. SEISMIC DESIGN CRITERIA:

18.1. The equipment shall be designed for operation in seismic zone for earthquake resistance. The seismic loads are due to the horizontal and vertical acceleration which may be assumed to act on concurrently. Seismic Qualification requirements shall be as per IEC 62271-207 for the design of equipment. The equipment along with its parts shall be strong enough and sufficiently well connected to resist total operating stresses resulting from the forces in normal operation, but in case of abnormal condition shall also resist with forces superimposed due to earthquakes. The copies of type test reports for similar rated equipment, if tested earlier, should be furnished. If the equipment has not been type tested earlier, Test Report/Analysis Report should be furnished.

18.2. To prevent the movement of GIS sub-assemblies i.e. various bay modules during the earthquake, suitable devices shall be provided for fixing the sub-assemblies to the foundation. The contractor shall supply necessary bolts for embedding in the concrete foundation. The fixing of GIS sub-assemblies to the foundation shall be designed to with-stand the seismic events. It will also be ensured that the special devices as well as bolts shall not be over stressed. The details of the devices used and the calculations for establishing the adequacy shall be furnished by the supplier and shall be subject to the employer's approval.

19. DESIGN REVIEW

19.1. Design reviews shall be conducted by Employer or an appointed consultant during the detailed Engineering of the GIS; however the entire responsibility of design shall be with the supplier.

19.2. Employer may also visit to the supplier's works to inspect design, manufacturing and test facilities.

19.3. The design review will commence after placement of award with the successful contractor and shall be finalized before commencement of manufacturing activity. These design reviews shall be carried out in detail to the specific design with reference of the GIS under the scope of this specification. Employer reserve the right to waive off the design review during detailed engineering.

19.4. The design review shall be conducted generally following the, "User Guide for the application of Gas Insulator Switchgear (GIS) rated voltage of 72.5kV and above" – CIGRE report No. 125 prepared by CIGRE Working Group 23.10.

19.5. The manufacturer will be required to demonstrate the use of adequate safety margins for thermal, mechanical, dielectric, insulation coordination and vibration etc. design to take into the account the uncertainties of his design and manufacturing processes.

19.6. The scope of such a design review shall at least include the following:

1.	Dielectric Stress of Solid Insulation like Gas Barrier, support insulator etc.
2.	Dielectric stress of SF6 Gas Volume.
3.	Mechanical strength of enclosure, expansion joints etc.
4.	Criteria for providing expansion joint.
5.	Sealing system
6.	Insulation coordination
7.	Thermal stress and resulting increase in gas pressure during short circuit condition.
8.	Earthing of enclosure w.r.t circulating current.
9.	Seismic design, as per IEC 62271-207
10.	Circuit Breaker.
11.	Isolator and Earth switch.

12.	Voltage transformer.
13.	Current Transformer.
14.	Surge Arrester.
15.	Bushing.
16.	Ducting.
17.	Corrosion protection .
18.	Electrical and physical Interfaces with substation .
19.	Testing capabilities.
20.	Inspection and test plan.
21.	Transport and storage.
22.	Maintainability.
23.	Site Test.

19.7. Further, the manufacturer shall furnish the following information

a) Details regarding the loosely distributed metallic particles within the GIS encapsulation and calculations of critical field strength for specific particles of defined mass and geometry.

b) Study report of VFTO generated for GIS installation.

c) The methodology and all the equipment for electrical partial discharge (PD) detection, including that mentioned in the specification else-where.

d) The calculations and documents in support of the average intensity of electromagnetic field on the surface of the enclosure above during detailed engineering.

e) The detailed criteria/ design regarding location of pressure relief devices/rupture diaphragms

f) Calculations to show that there is no Ferro resonance due to capacitance of GIS for the voltage transformers

g) Design calculation for simulated parameters for Seismic level as applicable

h) Insulation Coordination studies including studies to recommend for additional surge arrestor

i) Calculation in support of touch & step voltages in all enclosures and earthing of complete GIS installation.

j) Measures to mitigate transient enclosure voltage by high frequency currents.

k) Calculation for providing bus duct supports.

20. TYPE TESTS

The offered GIS equipment shall conform to the type tests as per IEC-62271-203. Contractor shall submit type test reports for the following type tests & additional type tests.

Sl.	Description of the Type Test for GIS

1	Tests to verify the insulation level of the equipment and dielectric test on auxiliary circuits
2	Tests to prove the temperature rise of any part of the equipment and measurement of the resistance of the main circuit
3	Tests to prove the ability of the main and earthing circuits to carry the rated peak and rated short time withstand current
4	Tests to verify the making and breaking capacity of the included switching devices
5	Tests to prove the satisfactory operation of the included switching devices
6	Tests to prove the strength of the enclosures
7	Gas tightness tests
8	Tests on partitions
9	Tests to prove the satisfactory operation at limit temperatures
10	Tests to assess the effects of arcing due to internal fault
11	Verification of the degree of protection of the enclosure
12	Tests to prove performance under thermal cycling and gas tightness tests on insulators
13	Additional tests on auxiliary and control circuits
14	Reactor current switching test
15	Test to demonstrate the Power frequency withstand capability of breaker in open condition at lock out pressure.
16	Electromagnetic compatibility tests (if applicable)
17	Radio inference voltage tests (RIV) , if applicable

The test reports of the above type tests for GIS (including type test report on Circuit breaker, Disconnectors, Grounding switches, Current and Voltage transformers as per relevant IEC and type tests of SF6/Air & Oil bushing as per IEC 60137 shall be submitted for approval as per Section- GTR, Technical Specification.

21. GENERAL

21.1. **Painting of enclosure**: All enclosures shall be painted externally as per manufacturer's painting procedure. The painting procedures as followed shall be submitted during detailed engineering.

21.2. **Heaters:** Wherever required, heaters shall be provided to prevent moisture condensation.

Heaters are not allowed inside the main circuit.

21.3. **Identification & rating plate**

Each bay shall have a nameplate showing

a) A listing of the basic equipment (such as a breaker, Disconnectors grounding switches, current transformers, voltage transformers, and bushings etc).

b) A schematic diagram indicating their relative locations.

c) NEA Contract Number.

d) Each module will have its own Identification & rating plate. The rating plate marking for each individual equipment like Circuit breaker, Disconnectors Grounding switches, Current transformer, Voltage transformers, Surge arrester etc shall be as per their relevant IEC.

22. TRANSPORT OF EQUIPMENT TO SITE

The contractor shall be responsible for the loading, transport, handling and offloading of all equipment and materials from the place of manufacture or supply to site. The contractor shall be responsible to select and verify the route, mode of transportation and make all necessary arrangement with the appropriate authorities as well as determining any transport restrictions and regulations imposed by the government and other local authorities. All transport packages containing critical units viz Circuit breakers and Voltage transformers shall be provided with sufficient number of electronic impact recorders (on returnable basis) during transportation to measure the magnitude and duration of the impact in all three directions. The acceptance criteria and limits of impact in all three directions which can be withstood by the equipment during transportation and handling shall be submitted by the contractor during detailed engineering. The recording shall commence in the factory and must continue till the units reach site. The data of electronic impact recorders shall be downloaded at site and a soft copy of it shall be handed over to Engineer – in –charge. Further, contractor shall communicate the interpretation of the data within three weeks.

23. PACKING, STORAGE AND UNPACKING

23.1. All 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 the variations in such conditions that will be encountered enroute from the manufacturer's works to the site.

23.2. The SF6 metal clad equipment shall be shipped in the largest factory assembled units that the transport and loading limitations and handling facilities on site will allow to reduce the erection and installation work on site to a minimum.

23.3. 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. Should the units be considered too large for packing in crates, they shall be suitably lagged and protected to prevent damage to any part, particularly small projections, during transport and handling. Special lugs or protective supports shall be provided for lifting to prevent slings and other lifting equipment from causing damage. Each crate, container or shipping unit shall be marked clearly on the outside to show where the weight is bearing and the correct position for the slings.

23.4. Each individual piece to be shipped, whether crate, container or large unit, shall be marked with a notation of the part or parts contained therein.

23.5. Special precautions shall be taken to protect any parts containing electrical insulation against the ingress of moisture. This applies particularly to the metal clad equipment of which each gas section shall be sealed and pressurized prior to shipping. Either dry nitrogen/air or dry SF6 gas 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. The type of gas, the maximum pressure to which sections will be filled prior to shipment and the minimum allowable pressure during shipment shall be advised prior to dispatch.

23.6. All blanking plates, caps, seals, etc., necessary for sealing the gas sections during shipment to site shall be provided as part of the contract and shall remain the property of OWNER. If considered necessary, blanking plates or other sealing devices shall be provided with facilities for measuring the gas pressure and recharging at any time during the transport period. Any seals, gaskets, 'O' rings, etc. that may 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. Identification serial numbers shall be stamped into the blanking plates, etc., and on the switchgear equipment to which they are fitted so that they can easily be identified and refitted should it ever be necessary to ship sections of the switchgear back to the manufacturer's works for repair.

23.7. Valves and other gas couplings associated with the switchgear gas systems shall be adequately protected against damage from any bumps or physical blows. They shall also be capped to prevent ingress of dirt or moisture or damage to any coupling, pipes, threads or special fittings. Any explosion vents and other pressure relief devices, shall be suitably sealed and protected to prevent accidental exposure of the sealed sections during shipment to site.

23.8. For bus ducts involving male and female joints of the current carrying conductor, the same shall be transported in disassembled condition to avoid any damage during transit. All bright parts liable to rust shall receive a coat of anti rusting composition and shall be suitably protected.

23.9. The contractor will be able to use the available storage areas at site. The contractor shall ensure that during the period between arrival at site and erection, all materials and parts of the contract works are suitably stored in such approved manner as to prevent damage by weather, corrosion, insects, vermin or fungoral growth. The scope of providing the necessary protection, storing off the ground, as required etc. is included in the works to be performed by the contractor.

23.10. The equipment shall only be unpacked or removed from the containers immediately prior to being installed. They shall not be left lying unnecessarily in open crates or containers. Special precautions shall be taken when gas sections which have been sealed and pressurized for shipping are opened up to reduce the ingress of dirt and atmospheric moisture to a minimum. Whenever possible this shall only be done immediately prior to installation and if any section is to be left outside for any length of time after being opened, it shall be resealed and pressurized with either dry nitrogen/air or SF6 gas until required.

24. INSTALLATION OF GIS

24.1. Civil works of GIS Hall shall be completed in all respects for taking up the installation and it shall be ensured that all dust and dirt in the hall are removed. All openings (including Bus Duct) except entry door should be closed and proper sealed

24.2. The installation area shall be secured against entry of unauthorized personnel. Only certified manufacturer's engineer and supervisor shall supervise critical & important erection works. The help of local technicians can be taken only for material handling and non-critical erection works. Engineers and supervisors of the manufacturer shall submit authorization and competency certificate to OWNER.

24.3. Assembly drawing for GIS erection for the section under progress shall be available and displayed in GIS hall at the time of work.

24.4. Proper power supply shall be ensured by installing DG Set of proper rating and frequency if required prior to commencement of erection work so that assembly work is not interrupted in the middle which is critical for GIS installation.

24.5. Working personnel shall clean their shoes or apply covers on shoes before entering the immediate working area. The working clothes of authorized personnel shall be made of non fluffy material.

24.6. GIS hall door shall have automatic close facility after entry of personnel to avoid dust and moisture entry. Walls and ceiling shall be in a condition so that neither dirt nor plaster might fall or rub off and formation of condensation water in ceiling shall be prevented under any circumstances.

24.7. Floor in the installation area shall have a firm surface and shall be kept dust free with a vacuum cleaner. Vacuum cleaning to be done at regular interval through out the day with separate team of persons assigned for cleaning work only.

24.8. Only T&P and consumables required for GIS erection shall be kept in GIS during erection.

24.9. In case of outdoor installation of GIS or of GIS components open gas compartments shall be protected from dust and moisture ingress (by tarpaulin covers etc)

24.10. Bus duct exit in the GIS hall wall shall be kept covered by suitable means until permanent cover is provided after installation of bus ducts.

24.11. A separate room shall be identified in consultation with NEA for carrying out repair works/ small part assembly and the room shall be weather protected and lockable. All excess material (not required for immediate installation works) test equipment and tools and tackles to be stored separately from GIS hall in the separate room for rework

24.12. All assembly work shall be done by qualified personnel only who are to be identified and list submitted to Owner site before starting of erection work.

24.13. Erection agency shall submit method statement and make available formats for checking during each stage of hall preparation, assembly process and final checks to be approved by OWNER site before start of erection. Method statement shall include record of shock/ impact recorder at the time of unpacking. Shock recorder down loaded data and analysis shall be submitted before commencement of erection work. In case of violation of shock limits, expert form manufacturer shall visit and do the internal inspection before giving clearance for erection.

24.14. Cleaning is of utmost importance and hence before assembly, all the loose metal parts, subassemblies and all contact& sealing surfaces shall be cleaned before installation. Cleaning shall be e carried out with specified cleaning agents of the manufacturer in no condition water is to be used except for external surfaces. Further, Prior to opening, gas compartment shall be thoroughly cleaned and vacuum cleaning of the installation area shall also be done specially the immediate vicinity of the flanges to be connected. Dust disturbance in the area to be avoided

Also, before closing a flange connection clean the immediate vicinity and all accessible parts of the components shall be connected with a vacuum cleaner

24.15. Once the transport covers are removed installation of flanges shall be done without any interruptions, if interruptions cannot be avoided open flanges are to be covered with clean plastic foil. Transport covers, O-rings and other packing material shall be taken out of GIS after immediately after removal.

24.16. O Rings shall be properly stored and taken out only before installation. O Rings are also to be cleaned before use with manufacturer authorized cleaning agent.

24.17. At all points of time during installation authorized personnel shall use disposable gloves to avoid contamination.

24.18. Cable termination work shall commence only after completion of GIS equipment as during GIS installation period laying and termination of cables interferes with the GIS erection work and affects cleanliness.

24.19. Approved Field Quality Plan shall be followed strictly during site work.

25. ON SITE TESTING

After the switchgear has been completely installed on site and filled with SF6 gas, the complete assembly shall be subjected to the site tests as per IEC – 62271-203 and with the test voltages specified below :-

25.1. The adequacy of number of UHF sensors and their location shall be verified as per recommendations of CIGRE task force **TF 15/33.03.05** (Task force on **Partial discharge detection system for GIS: Sensitivity verification for the UHF method and the acoustic method**). In case during site testing additional UHF sensors are required, the same shall also be supplied and installed to complete the technical requirement.

25.2. Application of AC voltage equal to 1.2 times the service voltage in order to condition the GIS whilst at the same time permitting measurement of Partial discharge and detection of conductive particles by UHF method.

25.3. In case of a disruptive discharge in the gas as outlined in clause no: C.6.2.2 Procedure b), annexure – C of IEC : 62271-203 , and a repeat test is performed due to failure during the AC voltage test , then the test shall be carried out at 1.2 times the service voltage .

The analysis of PD measured during High voltage test shall done very carefully and presence of PD measured by any sensor shall be attended and HV test shall be repeated after the rectification work. Calibration of PD sensors shall be completed before start of HV test to establish reference for detection of PD above 5 pc

25.4. Method statement/ procedure of onsite high voltage testing and PD measurement shall be submitted by contractor in advance.

25.5. On site testing: Pre-commissioning test procedure for the GIS shall be submitted to Owner for approval and done as per approve document.

26. TESTING & MAINTENACE EQUIPMENT

All testing & maintenance equipment shall be offered, if specified as per relevant schedule of BPS.

26.1. SF6 Gas leakage detector.

The detector shall be portable, battery operated with built in battery charger, 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, and a head phone jack. 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.

26.2. Gas filling and evacuating plant :

26.2.1. 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).

26.2.2. 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.

26.2.3. The minimum capacity of evacuation plant will be as under :

Vacuum Pump: 60 M^3/Hour (Nominal suction pressure)
Compressor : 15 M3/Hour(Delivery)

26.2.4. 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.

26.2.5. The gases compartments shall preferably be fitted with permanent non-return valves through which the gas is pumped into or evacuated form the compartments.

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

26.3. 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: +/- 0.5 %
- ii) Dew point - Range : -60 to +20 deg C & Accuracy: +/- 0.5 deg C
- iii) SO2 - Range : 0-150 ppm & Accuracy : +/- 2 %
- iv) CF4 – Range : 0-60% vol & Accuracy : +/- 1 %
- v) HF - Range : 0-200ppm & Accuracy : +/- 5 %

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

26.4. Portable Partial Discharge (PD) monitoring system (Shall generally applicable for 220kV&132 kV)

26.4.1. 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.

26.4.2. 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.

26.4.3. 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.

26.4.4. 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. Necessary training may be accorded to personnel to make use of the kit for locating PD sources inside the GIS
10. Instrument shall be robust and conform to relevant standard.

26.4.5. **Calibration:** The UHF Couplers have to be first calibrated as per CIGRE procedure TF 15/330305 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.

26.4.6. Pulse generator for UHF sensor sensitivity test shall also be supplied as a standard accessory.

26.5. Online Partial Discharge Monitoring System (Shall generally applicable for 400 kV)

26.5.1. GIS equipment shall be designed so as to minimize partial discharge or other electrical discharge. A state-of-the art Partial Discharge Monitoring system shall be provided to monitor the entire GIS installation.

26.5.2. An on-line continuous Partial Discharge Monitoring (PDM) system shall be designed to provide an automatic facility for the simultaneous collection of PD data at multiple points on the GIS & its associated GIB ducts and Voltage Transformers adopting UHF technique. The data stored shall provide a historical record of the progress of PD sources and shall identify the areas of maximum activity.

26.5.3. The scope shall cover Engineering, supply, installation, testing and commissioning of partial discharge continuous monitoring system, with all necessary auxiliaries and accessories to make a complete system as per technical specification, including site demonstration of successful operation. Any items/accessories necessary to make the system fully functional for the trouble free online PD monitoring of complete GIS installation shall be considered as included in the scope.

The PDM system shall be provided with capacity for readily interfacing with UHF PD couplers of present and future GIS Bays as shown in SLD plus 20% additional as spare. Details of it shall be submitted during engineering stage for approval. The PD Monitoring PC Work Station shall be housed in a lockable cabinet with duplicate keys and shall be located in the control room of the GIS substation. Workstation PCs shall be pre-loaded with all necessary Hardware & Software. The PCs shall have each Combo drive & Retrievable disk drive (1 TB), Ethernet port 100Mbps, printer. The workstation PC shall be powered by suitable dedicated UPS and same is included in the present scope.

26.5.4. Design of on-line PDM System

1. The technical proposal for PDM system along with detailed design documentation shall be submitted for EMPLOYER'S approval during engineering stage.
2. To guarantee that sufficient coverage is available for complete GIS installation to monitor PD activity all design details shall be submitted as part of the above for review.
3. The calibration and frequency response of couplers shall be as per NGC Technical Guidance note TGN (T) 121, issue 1, 1997. Data sheet shall be submitted for the UHF couplers meeting this requirement.
4. The sensitivity of the offered system shall be in accordance with CIGRE document for UHF detection TF 15/33.03.05 that will be verified as part of site sensitivity tests.
5. UHF attenuation data of GIS shall be submitted for the switching devices, spacers, bends etc.
6. The signal attenuation level of co-axial cable per meter length and justification for the length of cable connection between the couplers and detector units shall be furnished.
7. The overall sensitivity of PD detection system shall take into account the spacing between couplers and the associated cabling, filters, amplifiers, etc.
8. The Sub-station GIS layout as a separate drawing indicating position of spacers, spread over of PD sensors with distance, sensor identification, the detector unit identification etc. shall be submitted during engineering stage for approval.
9. The PD sensors shall be identified / coordinated with the corresponding detector unit etc. with proper identification labeling and indicated in the substation PDM SLD.
10. Internal arrangement/wiring diagram is to be submitted for detector units/control cabinet etc. All internal items are to be identified / labeled to facilitate troubleshooting.
11. Supply requirement (AC & DC) to be specified for the complete monitoring system.
12. Power supply to PDM PC shall have protection against surges, overload and short circuit. A dedicated on-line UPS system shall also be provided as a backup during supply interruption, to ensure trouble-free & reliable running of the PDM System for

a minimum of 15 minutes duration. Ratings of UPS shall be proposed for the approval of EMPLOYER'S. The UPS shall have enough capacity to initiate a 'safe' shut down of the PDM PC and the peripherals after this 15-minute period if normal supply fails to resume. The PDM PCs shall restart automatically on resumption of normal supply. The UPS shall not generate spikes during changeover of supply. UPS shall automatically give indication / alarm when it requires battery replacement. Potential Free Contacts shall be generated to signal these events. These contacts shall be wired out to Annunciation / Monitoring systems. Alternately, inverter of suitable capacity is also acceptable. Critical Process and Status alarms of the PDM system shall be displayed.

13. PDM System shall be provided with a user security for accessing the system with a log-on and password entry procedure. The user levels shall be defined as a Master User and other users for the modification of system, update, and entry of parameters or manual operation. System shall be able to generate 3D point on wave pattern whenever any PD activity detected by the system. System shall be able to give online 3D point on wave pattern, online PRPD (phase resolved PD) and online short time trend etc. System shall be able to generate the all the logs related to system fault, system access, PD event, and any changes in system setting etc.
14. Method of electrical isolation/protection provided between PD sensor and detector circuitry in case of flashover/high potential stress inside GIS should be furnished.
15. The selected mode of propagation of PD signal (electromagnetic wave) inside GIS for the design of sensors shall be furnished.
16. The protection available for electronics against transient over voltages caused by switching operations shall be furnished.
17. The capacity of each detector unit to be specified to accommodate as many numbers of PD sensors signal.
18. The applicable standards to meet IEC & IEEE requirements for electromagnetic compatibility shall be specified. The offered system should have been tested for the same for working in a 400kV & above substation environment. The necessary documentation has to be submitted in this regard.
19. Guaranteed technical particulars & data sheet for various components used in the system shall be submitted.

26.5.5. **Calibration:** The UHF Couplers have to be first calibrated as per CIGRE procedure TF 15/330305 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.

26.5.6. **Every Day Use & Maintenance** : The system shall be designed suitable for an unmanned s/s and operate automatically. The system shall generate alarms if suspected partial discharge activity is noticed or the system itself is in failure, thereby eliminating the necessity of periodic system access by the user and one such alarm shall be connected to Substation automation system (SAS). The alarms shall be configured coupler wise.

26.5.7. **Computers and Peripherals:** The PC operating system shall be the latest version of MS Windows. It should be suitable for continuous process application and should have been tested for the same. The hardware configuration of PC should be the latest available in the market of industrial type subject to EMPLOYER'S / Engineer approval. For storing the historical PD database, sufficient storage facility in the form of hard disc and retrievable hard disk drive of 1TB as specified shall be available in the substation. The PC monitor shall be 21" LCD type of reputed make.

26.5.8. **Filtering Facility:** The filtering facility has to be provided in order to distinguish real PD from internal/external noise such as switching operations, self-test signal, radio, communication signal etc. The PDM system itself shall be able to discriminate the noise from real PD. The exposed gas barriers of the GIS shall be shielded effectively against noise interference & tested. The gas barrier shields/belts shall be suitable for outdoor use also & able to withstand high ambient temperature. Site measurements have to be performed after installation of the PDM system in order to identify the various sources of external noise to incorporate the same in the filtering facility. This filtering will preferably be through software by band pass, which can be manually activated (as an option) to filter out noise signals in the trend plot display. If hardware filtering is employed then adequate measures have to be taken to avoid masking of other signals, which may lie in the same frequency range. The method adopted for the above shall be specified taking into account the sensitivity requirement of PDM system as per CIGRE document. The noise filters shall be selectable individually coupler-wise.

26.5.9. **Self-Test (Diagnostic) Facility**: Built-in self-checking facility shall be incorporated in the control system which will continuously verify the correct operation of the whole monitoring system with the simulated PD signal viz. checking of the sensitivity of individual detector units, response of PD sensors in addition to the checking of the system functioning. The periodicity of such self-check operation shall be specified. In case of system failure this shall trigger an alarm for communication to SAS. External check facility: Propose the arrangement/device available for externally checking the healthiness of PD sensors by pulse injection in addition to built-in monitoring facility.

26.5.10. **Detector Units**: The sensitivity of each detector unit shall be furnished. The sensitivity level of individual detector units shall be selectable depending on the site background noise level.

26.5.11. **Trend Plot**: The trend plot facility shall be available with the update period of hourly/daily/weekly/monthly/yearly. It shall be possible to view the historical trends for the complete archived data accumulated over several years.

26.5.12. **PD Monitoring modes**: There shall be two different modes of system operation viz. a dedicated Continuous PD Monitoring mode for the normal day today operation of the system & a dedicated HV commissioning test mode which is exclusively for PD monitoring during HV commissioning test. The HV commissioning mode shall also operate as an independent feature.

In the HV Commissioning mode the real time display shall be possible for a minimum of two complete bays with associated bus bars and at with one second update period. The HV test software shall automatically record the HV voltage information along with PD so as to check PD inception & extinction voltages precisely. The complete HV & PD data recorded during HV test shall be possible to be reviewed in replay mode after the HV test.

26.5.13. **Alarm Facility:** The PDM system shall generate alarm when action is required; viz. a) PD alarm (abnormal PD activity indicating a risk of failure) & b) PD system fail alarm to be connected to SAS.

26.5.14. **Real Time Display:** The PDM system should have the facility of Real Time display, which will give an instant indication of PD activity coupler wise, with one-second- update period. The PDM system shall be able to capture the PD data triggered by associated switching operations of CBs & isolators.

26.5.15. **Schematics: The** PDM system should have GIS schemes bay-wise incorporating PD sensor identification and location along with spacer location. The sectional view of typical bay arrangement of GIS showing active parts shall also be included as part of the PDM software.

26.5.16. **Print Option/Facility:** PDM system should have the option/facility of printing all trend plots/reports/POW patterns/displays, etc. Laser Colour printer shall be provided for this purpose at substation.

26.5.17. **Data Archives:** This is to provide access to historical data and file storage with date and time stamp. Sufficient storage facility shall be available to review historical data updated for the lifetime of switchgear. The substation & headquarters PCs shall have a backup device in the form of a retrievable disk drive of 1TB capacity for this purpose.

26.5.18. PD Fault Identification & Location/Pattern Recognition/Predictive Maintenance

Diagnostic Software: In order to interpret various types of PD defects, intelligent diagnostics software (expert system) shall be built- in as part of the PDM software capability. This is mainly to reduce the dependence on PD specialist. The bidder shall also make available typical point-on-wave patters as library pictures to train the user.

Software Updates: It shall be possible to upgrade / update the system software throughout the lifetime of the system with the ongoing development / refinement in PD technology.

26.5.19. Fault investigation : In case of any indication of suspected PD activity by the on line system, further investigation has to be carried out by the contractor for the PD defect identification and location during the warranty period

26.5.20. Special Tools / equipment, Spare Parts, software packages

Special Tools: Special tools for cutting and crimping of coaxial cable with 'N Connectors' shall be supplied.

Spare parts: The contractor has to supply critical spares with replacement procedure for the trouble free operation of the system during its expected lifetime as part of the contract. A detailed list shall be included in the tender and also submitted for EMPLOYER'S approval during the detailed engineering stage.

Software Packages: The complete software package shall be supplied as part of a back-up facility in the form of DVD/CDs viz. Windows operating system with end user license, PDM Software including HV Test, Drivers for modems etc., software for remote access, printer etc. The list shall be submitted for reference.

Pulse generator for UHF sensor sensitivity test shall also be supplied as a standard accessory.

26.5.21. Operation & Maintenance Manual :A complete O&M manual covering all aspects of trouble shooting of PDM system in six sets in original shall be provided & also in CD's. For diagram references colour pictures shall be provided. A step-by-step procedure for spare parts replacement shall also be included.

26.5.22. **Factory / Site Test Formats**: The factory & site tests format to be submitted for approval. The format shall cover all possible tests to confirm healthiness of the system and to record the test values.

26.5.23. List of References: The bidder shall provide a reference list of PD monitoring system, which is supplied by them and in successful operation worldwide in a power utility.

27.0 Support Services

Throughout design, implementation, factory testing, and field installation and testing, the Contractor shall supply consulting assistance, as required by the Employer for site preparation, field installation, and other areas where technical support may be required. The Contractor shall be responsible for minor facility renovation, and maintenance of the supplied system up to and including successful completion of the Site Acceptance Test. After final acceptance of the GIS equipment, the Contractor shall offer continuing technical support and spare parts up to 5 years.

27.1 Technical Support

Consultation with Contractor's technical support personnel and trained field service personnel shall be readily available on a short-term/long-term basis to assist the Employer personnel in maintaining, expanding, and enhancing the GIS System upon expiration of the defect liability period. The Contractor shall include in their offer(s), a proposal for ensuring continued technical support as stated above.

TECHNICAL PARAMETERS FOR CIRCUIT BREAKER **ANNEXURE-1**

S. N.	Parameter	400kV system	220kV system	132 kV system
1.	Rated voltage kV (rms)	420	245	145
2.	Rated frequency (Hz)	50	50	50
3.	No. of poles	3	3	3
4.	Type of circuit breaker	SF6 insulated.	SF6 insulated.	SF6 insulated.
5.	**Rated continuous current (A) at an ambient temperature of 50^{0}C**	**2000/3150/4000 (as applicable)**	**1600/3000 (as applicable)**	**1250/600 (for line/bus-coupler /Tr. Bay-breaker) (as applicable)**
6.	Rated short circuit capacity with percentage of DC component as per IEC-62271-100 corresponding to minimum opening conditions as specified.	50 (As applicable)	40 kA (As applicable)	31.5 kA (As applicable)
7.	Symmetrical interrupting capability kA (rms) (As applicable)	50	40	31.5
8.	Rated short circuit making current kAp (As applicable)	157.5/125/100	125/100	80
9.	Short time current carrying capability for one second kA (rms) (As applicable)	63/50/40	50/40	80
10.	Rated line charging interrupting current at 90 deg. Leading power factor angle (A rms) (The breaker shall be able to interrupt the rated linecharging current with test voltage immediately before opening equal to the product of U/√3 and 1.4 as per IEC-62271-100	600	As per IEC	As per IEC
11.	First pole to clear factor	1.3	1.3	As per IEC
12.	Rated break time as IEC (ms)	40	60	60

S. N.	Parameter	400kV system	220kV system	132 kV system
13.	Total break time (ms)	45	65	65
14.	Total closing time	Not more than	Not more than	Not more than
15.	Rated operating duty cycle	O-0.3s-CO-3 min-CO	O-0.3s-CO-3 min-CO	
16.	Reclosing	Single phase &Three phase auto	Single phase &Three phase	Single phase &Three phase
17.	Pre-insertion resistor requirement			
	Rating (ohms)	400Ω	NA	NA
	Minimum pre-insertion time (ms)	8	NA	NA
	Opening of PIR contacts	PIR contacts should open immediately after closing of main contacts OR At least 5 ms before opening of main contacts at rated gas pressure where the PIR contact remain closed	NA	NA
18.	**Rated insulation levels**			
	Full wave impulse withstand (1.2 /50 µs) between	± 1425 kVp	±1050 kVp	± 650 kVp
19.	Full wave impulse withstand (1.2 /50 µs) Between terminals with circuit breaker open:	± 1425 kVp impulse on one terminal & 457 kVp of opposite polarity on the other	±1050 kVp	± 750kVp
	Rated switching impulse withstand voltage (250/2500 µs) Dry & wet.	±1050 kVp	NA	NA
	Rated switching impulse withstand voltage (250/2500 µs) Dry &wet Between terminals with circuit breaker open:	±900 kVp impulse on one terminal & 345 kVp of opposite polarity on the other terminal	NA	NA

S. N.	Parameter	400kV system	220kV system	132 kV system
	One minute power frequency withstand voltage between line terminals and ground	650 kV rms.	460 kV rms.	275 kV rms
	One minute power frequency withstand voltage between terminals with circuit breaker open	815 kV rms.	530 kV rms.	315 kV rms
	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz at 266 kV (Micro volts)	1000 µV	1000 µV	500µV
20.	Max. difference in the instants of closing/opening of contacts (ms) between poles	As per IEC	As per IEC	As per IEC
21.	Trip coil and closing coil voltage with variation as specified in Sec. GTR	220 V DC	220 V DC	220 V DC
22.	Rating of Auxiliary contacts	10A at 220 V DC	10A at 220 V DC	10A at 220 V DC
23.	Breaking capacity of Aux. Contacts less than 20 ms.	10A at 220 V DC	10A at 220 V DC	10A at 220 V DC
24.	System neutral earthing	Solidly Grounded		

TECHNICAL PARAMETERS FOR DISCONNECTORS/ ISOLATORS ***ANNEXURE-2***

S. N.	Particulars	400 kV	220 kV	132kV
1.	Rated voltage (rms) Un	420 kV	245 kV	145 kV
2.	Rated frequency	50 HZ	50 HZ	50 Hz
3.	System earthing	Effectively earthed	Effectively earthed	Effectively earthed
4.	Type	SF6 insulated	SF6 insulated	SF6 insulated
5.	Rated continuous current (A) at 50^{0}C ambient temp.(as applicable)	2000/3150/4000	1600/3000 (as applicable)	1200/600 (for line /transformer /bus coupler)
6.	Rated short time withstand current of isolator and earth switch(as applicable)	63/50/40 kA for 1 Sec.	50/40 kA for 1 Sec.	31.5 kA for 1 second
7.	Rated dynamic short circuit withstand current withstand current of isolator and earth switch(As applicable)	157.5/125/100 kAp	1125/00 kAp.(As applicable)	80 kAp
8.	Rated insulation level:			
	One minute power freq. Withstand voltage: To earth :	650 kV rms.	460 kV rms.	275 kV rms.
	One minute power freq. Withstand	815 kV rms.	530 kV rms.	315 kV rms.
	voltage: Across isolating distance			
	1.2/50 micro sec. Lighting impulse withstand voltage (+ve or –ve polarity) To earth:	1425 kVp	$\pm$1050 kVp	$\pm$650 kVp

S. N.	Particulars	400 kV	220 kV	132kV
	1.2/50 micro sec. Lighting impulse withstand voltage (+ve or –ve polarity) : Across Isolating distance	±1425/-+240 kVp	±1200 kVp	±750 kVp
	Rated switching impulse withstand voltage (250/2500 micro-sec.) Dry & wet :between line terminals and ground:	+/- 1050 kVp	N.A	N.A
	Rated switching impulse withstand voltage (250/2500 micro-sec.) Dry & wet :Between terminals with Isolator open:	+/- 900 kVp impulse on one terminal & 345 kVp of opposite polarity on the other terminal.	N.A	N.A
9.	Mechanical Endurance clause as per IEC	M2	M2	M1
10.	No. of spare auxiliary contacts on each isolator	4 NO and 4 NC	4 NO and 4 NC	4 NO and 4 NC
11.	No. of spare auxiliary contacts on each earthing switch	4 NO and 4 NC	4 NO and 4 NC	4 NO and 4 NC

ANNEXURE-3

TECHNICAL PARAMETERS FOR CURRENT TRANSFORMERS

Sl no	Particular	400 kV	220 kV	132kV
1.	Rated voltage Un	420 kV (rms)	245 kV (rms)	145 KV (rms)
2.	Rated frequency	50 HZ	50 Hz	50 Hz
3.	System neutral earthing	Effectively earthed		
4.	Rated short time thermal current for 1 second (as applicable)	63/ 50/ 40 kA.	40 kA	31.5 kA
5.	Rated dynamic current	157.5/125/100	100 kAp.	78.75kA
6.	Rated insulation levels			
i.	1.2/50 micro second impulse voltage	±1425 kVp	±1050 kVp	±650 kVp
ii.	one minute power frequency withstand voltage	650 kV(rms)	460 kV (rms)	275 kV (rms)
7.	Maximum temperature rise over an ambient temperature of 40^0C	As per IEC 60044-1	As per IEC 60044-1	As per IEC 60044-1
8.	Radio interference voltage at 1.1 Un/√3 and frequency range 0.5 to 2 MHz	1000 µV	1000 µV	500µV
9.	One minute power frequency withstand voltage between sec. Terminal & earth	3 kV (rms)	3 kV (rms)	3 kV (rms
10.	Partial discharge level	5 pico coulombs	5 pico coulombs	5 pico coulombs

REQUIREMENTS FOR 400 kV CURRENT TRANSFORMER (TABLE-3A)

No. of cores	Core no.	Application	Current ratio	Output Burden (VA)	Accuracy Class	Min. Knee pt. Voltage Vk	Max. CT Sec. Wdg. Resistance (ohm)	Max. Excitation current at Vk (in mA)	Remarks
6	1	BUS DIFF CHECK	4000-2000-500/1	-	TPS*	4000/ 2000/ 500	15/10/2.5	20 on 4000/1tap. 30 on 2000/1tap. 120 on 500/1tap	
	2	BUS DIFF MAIN	4000-2000-500/1	-	TPS*	4000/ 2000/ 500	15/10/2.5	20 on 4000/1tap. 30 on 2000/1tap. 120 on 500/1tap	
	3	METERING	4000-2000-500/1	20 20 20	0.2S 0.2S 0.2S	-	-	-	
	4	METERING	4000-2000-500/1	20 20 20	0.2S 0.2S 0.2S	-	-	-	
	5	TRANS BACK UP/ LINE PRTN.	4000-2000-500/1	-	-	4000/ 2000/ 500	15/10/2.5	20 on 4000/1tap. 30 on 2000/1tap. 120 on 500/1tap	
	6	TRANS DIFF/ LINE PRTN.	4000-2000-500/1	-	-	4000/ 2000/ 500	15/10/2.5	20 on 4000/1tap. 30 on 2000/1tap. 120 on 500/1tap	

Note:

- *All protection Cores shall be of accuracy class TPS as per IEC: 60044-6. However, if a higher accuracy class CT is required for protection, the same shall be provided.
- The CT ratios given above is the basic information to the bidders which shall be optimized during the details engineering.

ANNEXURE-4

TECHNICAL PARAMETERS FOR VOLTAGE TRANSFORMERS

Sl. No.	Particular	400 kV	220 kV	132kV
1	Rated system voltage (Un)	420 kV (rms)	245 kV (rms)	145 KV (rms)
2	Rated frequency	50 HZ	50 Hz	50 Hz
3	System neutral earthing	Effectively earthed	Effectively earthed	Effectively earthed
4	System fault level	50/40 kAp.(As applicable) for 1 Second.	50/40 kAp.(As applicable)for 1 Second.	31.5 kA
5	Rated insulation levels			
i.	1.2/50 micro second impulse voltage	±1425 kVp	±1050 kVp	±650 kVp
ii.	one minute power frequency withstand voltage	650 kV(rms)	460 kV (rms)	275 kV (rms)
iii.	250/2500 micro second switching impulse voltage (dry & wet)	1050 kVp	NA	NA
6	One minute power frequency withstand voltage for secondary winding	3 kV (rms)	3 kV (rms)	3 kV(rms)
7	Radio interference voltage at 1.1 Un/√3 and frequency range 0.5 to 2 MHz	1000 µV	1000 µV	500µV
8	Rated total thermal burden	400 VA	400 VA	
9	Partial discharge level	10 Pico coulombs.	10 Pico coulombs.	10 pico coloumbs

REQUIREMENT OF VOLTAGE TRANSFORMERS (TABLE -4A)

S. N.	**PARTICUL ARS**	**400 kV**			**220 kV**			**132kV**		
1	Rated primary voltage	400/√3 kV			220/√3 kV			132//√3 kV		
2	Type	Electromagnetic			Electromagnetic			Electromagnetic		
3	No. of secondaries	3			3			3		
4	Rated voltage factor	1.2 continuous			1.2 continuous			1.2 continuous		
		1.5 for 30 seconds			1.5 for 30 seconds			1.5 for 30 seconds		
5	Phase angle error	±10 minutes (for metering core)			±10 minutes (for metering core)			±10 minutes (for metering core)		
		Sec I	Sec II	Sec III	Sec I	Sec II	Sec III	Sec I	Sec II	Sec III
6	Rated secondary voltage (V)	110/ √3	110/ √3	110/ √3	110/ √3	110/ √3	110/ √3	110/ √3	110/ √3	110/ √3
7	Application	Prote ction	Prote ction	Meterin g	Protecti on	Protecti on	Metering	Prote ction	Prote ction	Mete ring
8	Accuracy	0.5/3 P	0.5/3 P	0.2	3P	3P	0.2	3P	3P	0.2
9	Output burden (VA) (minimum)	50	50	50	50	50	50	50	50	50

TECHNICAL PARAMETERS OF GIS SURGE ARRESTOR ***ANNEXURE-5***

Sl. No.	Particulars	400 kV	220 kV	132 kV
1	Rated system voltage	420 kV	245 kV	132kV
2	System neutral earthing	Effectively earthed	Effectively earthed	Effectively earthed
3	Rated arrestor voltage	336kV	216 kV	120 kV
4	Nominal discharge current	20 kA of 8/20 µs wave	10 kA of 8/20 µs wave	10 kA of 8/20 µs wave
5	Rated frequency	50 Hz	50 Hz	50 Hz
6	Minimum discharge capability voltage corresponding to minimum discharge characteristics	12 KJ/kV at rated arrestor voltage or as decided in operating duty test	5 KJ/kV (referred to rated arrestor)	5 KJ/kV (referred to rated arrestor)
7	Continuous operating voltage at 50^0C	267kV	168 kV	102 kV
8	Min. switching surge residual voltage	670 kVp (2kA)	-	
	Max. switching surge residual voltage	650 kVp (500A)	500 kVp	280kVp
9	Max. residual voltage at 5 kA	-	560 kVp	310kVp
11	Max. residual voltage at 10 kA nominal discharge current	800 kVp	600 kVp	330 kVp
12	Max. residual voltage at 20 kA nominal discharge current	850 kVp	-	
13	Steep fronted wave residual voltage	925 kVp at 20kA	650kVp 10kA	

Sl. No.	**Particulars**	**400 kV**	**220 kV**	**132 kV**
14	Long duration discharge class	4 As per clause 10.3.4	3	3
15	High current short duration test value (4/10 micro second wave)	100 kAp	100 kAp	100 kAp
16	Current for pressure relief test	50kA/50kA (as applicable)	50kA/50kA (as applicable)	31.5 kA
17	Prospective symmetrical fault current	40/50/63 kA rms for 0.2 Sec	40 kA rms for 0.2 Sec	As per IEC
18	Pressure relief class:	A	A	A
19	RIV at 1.1 $U_n/\sqrt{3}$ kV rms(micro volts)	Less than 1000	Less than 500	Less than 500
20	Partial discharge at 1.05 COV (pC)	Not more than 5	Not more than 5	Not more than 5
21	Reference ambient temp.	50 ^{0}C	50 ^{0}C	50 ^{0}C

TECHNICAL PARAMETERS FOR SF6/AIR BUSHING ***ANNEXURE-6***

Sl. No.	Particular	400 kV	220 kV	132kV
1	Rated Voltage (kV)	420 kV (rms)	245 kV (rms)	145 kV (rms)
2	Rated Current (Amp)	2000/3150/ 4000 as applicable	1600	600
3	1.2/50 micro second impulse voltage (Lightning impulse withstand voltage)	1425 kVp	1050 kVp	630 kVp
4	250/2500 micro second switching impulse voltage	1050 kVp	-	
5	One minute power frequency withstand voltage	650 kV (rms)		275 kV (rms)
6	Minimum total Creepage distance in mm	10500	6125	3625
7	Minimum Cantilever strength (kN)	10	8	5

CHAPTER 4
Outdoor Switchgear

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SECTION 1 - CIRCUIT BREAKERS

1.0 GENERAL

1.1 The circuit breakers and accessories shall conform to IEC: 62271-100, IEC: 62271-01 and other relevant IEC standards except to the extent explicitly modified in the specification and shall also be in accordance with requirements specified in Chapter 2-GTR.

1.2 245/145/72.5/36 kV live tank type circuit breakers offered would be of sulphur hexafluoride (SF6) type only and of class C2-M2 as per IEC.

1.3 The circuit breaker shall be complete with terminal connectors, operating mechanism, control cabinets, piping, interpole cable, cable accessories like glands, terminal blocks, marking ferrules, lugs, pressure gauges, density monitors (with graduated scale), galvanised support structure for CB and control cabinets, their foundation bolts and all other circuit breaker accessories required for carrying out all the functions the CB is required to perform.

All necessary parts to provide a complete and operable circuit breaker installation such as main equipment, terminals, control parts, connectors and other devices whether specifically called for herein or not shall be provided.

1.4 Painting shall be done in line with Chapter 2 –GTR. REL-5032 or similar shades can be used for painting. The support structure of circuit breaker shall be hot dip galvanised. Exposed hardware items shall be hot dip galvanised or Electro-galvanised.

1.5 The circuit breakers shall be designed for use in the geographic and meteorological conditions as given in Chapter 2-GTR.

2.0 DUTY REQUIREMENTS:

2.1 The circuit breakers shall be capable of performing their duties without opening resistors.

2.2 The circuit breaker shall meet the duty requirements for any type of fault or fault location also for line switching when used on a 245/145/72.5/36 kV effectively grounded system, and perform make and break operations as per the stipulated duty cycles satisfactorily.

2.3 The breaker shall be capable of interrupting the steady state and transient magnetising current corresponding of power transformers.

2.4 The circuit breaker shall also be capable of:

i) Interrupting line/cable charging current as per IEC without use of opening resistors.

ii) Clearing short line fault (Kilometric faults) with source impedance behind the bus equivalent to symmetrical fault current specified.

iii) Breaking 25% of the rated fault current at twice rated voltage under phase opposition condition.

2.5 The Breaker shall satisfactorily withstand the high stresses imposed on them during fault clearing, load rejection and re-energisation of lines with trapped charges. The breaker shall also withstand the voltages specified under Clause 15 of this Chapter.

3.0 TOTAL BREAK TIME:

3.1 The total break time as specified under this Chapter shall not be exceeded under any of the following duties:

i) Test duties T10, T30, T60, T100a, T100s (TRV as per IEC: 62271-100)

ii) Short line fault L75, L90 (- do -)

3.2 The Bidder may please note that total break time of the breaker shall not be exceeded under any duty conditions specified such as with the combined variation of the trip coil voltage, (70-110%) and arc extinguishing medium pressure etc. While furnishing the proof of the total break time of complete circuit breaker, the Bidders may specifically bring out the effect of non-simultaneity between contacts between poles and show how it is covered in the guaranteed total break time.

3.3 The values guaranteed shall be supported with the type test reports.

4.0 CONSTRUCTIONAL FEATURES:

The features and constructional details of circuit breakers shall be in accordance with requirements stated hereunder:

4.1 **Contacts**

4.1.1 The gap between the open contacts shall be such that it can withstand atleast the rated phase to ground voltage for 8 hours at zero gauge pressure of SF6 gas due to the leakage. The breaker should be able to withstand all dielectric stresses imposed on it in open condition at lock out pressure continuously (i.e. 2 p.u. across the breaker continuously, for validation of which a power frequency dielectric with stand test conducted for a duration of at least 15 minutes is acceptable).

4.2 **The SF6 Circuit Breaker shall meet the following additional requirements:**

a) The circuit breaker shall be single pressure type. The design and construction of the circuit breaker shall be such that there is a minimum possibility of gas leakage and entry of moisture. There should not be any condensation of SF6 gas on the internal insulating surfaces of the circuit breaker.

b) All gasketted surfaces shall be smooth, straight and reinforced, if necessary, to minimise distortion and to make a tight seal, the operating rod connecting the operating mechanism to the arc chamber (SF6 media) shall have adequate seals. The SF6 gas leakage should not exceed 0.5% per year and the leakage rate shall be guaranteed for at least 10 years. In case the leakage under the specified conditions is found to be greater than 0.5% after one year of commissioning of circuit breaker, the manufacturer will have to supply free of cost, the total gas requirement for subsequent ten (10) years, based on actual leakage observed during first year of operation after commissioning.

c) In the interrupter assembly there shall be an absorbing product box to minimise the effect of SF6 decomposition products and moisture. The material used in the construction of the circuit breakers shall be fully compatible with SF6 gas decomposition products.

d) Each pole shall form an enclosure filled with SF6 gas independent of two other poles (for 245 kV CBs) and the SF6 density of each pole shall be monitored. For CBs of voltage class of 145 kV or less, a common SF6 scheme/density monitor shall be acceptable.

e) The dial type SF6 density monitor shall be adequately temperature compensated to model the pressure changes due to variations in ambient temperature within the body of circuit breaker as a whole. The density monitor shall have graduated scale and shall meet the following requirements:

   i) It shall be possible to dismantle the density monitor for checking/replacement without draining the SF6 gas by providing suitable interlocked non return valve coupling.

f) Each Circuit Breaker shall be capable of withstanding a vacuum of minimum 8 millibars without distortion or failure of any part.

g) Sufficient SF6 gas including that will be required for gas analysis during filling shall be provided to fill all the circuit breakers installed.

In addition spare gas shall be supplied in separate unused cylinders as per requirement specified in Chapter 1- PSR.

4.3 Provisions shall be made for attaching an operational analyser to record contact travel, speed and making measurement of operating timings, preinsertion timings of closing resisters if used, synchronisation of contacts in one pole.

5.0 SULPHUR HEXAFLUORIDE GAS (SF6 GAS):

a) The SF6 gas shall comply with IEC 60376, 60376A and 60376B and shall be suitable in all respects for use in the switchgear under the operating conditions.

b) The high pressure cylinders in which the SF6 gas is shipped and stored at site shall comply with requirements of the relevant standards and regulations.

c) Test: SF6 gas shall be tested for purity, dew point, air, hydrolysable fluorides and water content as per IEC 60376, 60376A and 60376B and test certificates shall be furnished to Employer indicating all the tests as per IEC 60376 for each lot of SF6 gas in stipulated copies as indicated in Chapter-GTR. Gas bottles should be tested for leakage during receipt at site.

6.0 INSULATORS:

a) The porcelain of the insulators shall conform to the requirements stipulated under Chapter 2-GTR.

b) The mechanical characteristics of insulators shall match with the requirements specified under this Chapter.

c) All hollow insulators shall conform to IEC-62155.

d) Hollow Porcelain for pressurised columns/chambers should be in one integral piece in green and fired stage.

7.0 SPARE PARTS AND MANDATORY MAINTENANCE EQUIPMENT:

The bidder shall include in his proposal spare parts and maintenance equipment in accordance with Chapter 1-PSR. Calibration certificates of each maintenance equipment shall be supplied alongwith the equipment.

8.0 OPERATING MECHANISM AND CONTROL

8.1 **General Requirements**

8.1.1 Circuit breaker shall be operated by spring charged mechanism or hydraulic mechanism or a combination of these. The mechanism shall be housed in a weather proof and dust proof control cabinet as stipulated in Chapter 2-GTR.

8.1.2 The operating mechanism shall be strong, rigid, not subject to rebound.

8.1.3 The mechanism shall be antipumping and trip free (as per IEC definition) under every method of closing.

8.1.4 The mechanism shall be such that the failure of any auxiliary spring will not prevent tripping and will not cause trip or closing operation of the power operating devices.

8.1.5 A mechanical indicator shall be provided to show open and close position of the breaker. It shall be located in a position where it will be visible to a man standing on the ground level with the mechanism housing closed. An operation counter shall also be provided in the central control cabinet.

8.1.6 Working parts of the mechanism shall be corrosion resisting material, bearings which require grease shall be equipped with pressure type grease fittings. Bearing pin, bolts, nuts and other parts shall be adequately pinned or locked to prevent loosening or changing adjustment with repeated operation of the breaker.

8.1.7 The bidder shall furnish detailed operation and maintenance manual of the mechanism alongwith the operation manual for the circuit breaker. The instruction manuals shall contain exploded diagrams with complete storage, handling, erection, commissioning, troubleshooting, servicing and overhauling instructions.

8.2 **Control:**

8.2.1 The close and trip circuits shall be designed to permit use of momentary contact switches and push buttons.

8.2.2 Each breaker shall be provided with two (2) independent tripping circuits, pressure switches and coils each to be fed from separate DC sources and connected to a different set of protective relays.

8.2.3 The breaker shall normally be operated by remote electrical control. Electrical tripping shall be performed by shunt trip coils. However, provisions shall be made for local electrical control. For this purpose a local/remote selector switch and close and trip control switch/push buttons shall be provided in the Breaker central control cabinet.

8.2.4 The trip coils shall be suitable for trip circuit supervision during both open and close position of breaker. The trip circuit supervision relay would be provided on relay panels.

8.2.5 Closing coil and associated circuits shall operate correctly at all values of voltage between 85% and 110% of the rated voltage. Shunt trip coil and associated circuits shall operate correctly under all operating conditions of the circuit breaker upto the rated breaking capacity of the circuit breaker and at all values of supply voltage between 70% and 110% of rated voltage. However, even at 50% of rated voltage the breaker shall be able to open. If additional elements are introduced in the trip coil circuit their successful operation and reliability for similar applications on outdoor circuit breakers shall be clearly brought out in the additional information schedules.

8.2.6 Density Monitor contacts and pressure switch contact shall be suitable for direct use as permissive in closing and tripping circuits. The density monitor shall be placed suitably inclined in such a way so that the readings are visible from ground level with or without using binoculars. Separate contacts have to be used for each of tripping and closing circuits. If contacts are not suitably rated and multiplying relays are used then fail safe logic/schemes are to be employed. DC supplies for all auxiliary circuits shall be monitored and provision shall be made for remote annunciations and operation lockout in case of D.C. failures. Density monitors are to be so mounted that the contacts do not change on vibration during operation of circuit Breaker.

8.2.7 The auxiliary switch of the breaker shall be positively driven by the breaker operating rod.

8.3 **Spring operated mechanism:**

a) Spring operated mechanism shall be complete with motor in accordance with Chapter 2 -GTR. Opening spring and closing spring with limit switch for automatic charging and other necessary accessories to make the mechanism a complete operating unit shall also be provided.

b) As long as power is available to the motor, a continuous sequence of the closing and opening operations shall be possible. The motor shall have adequate thermal rating for this duty.

c) After failure of power supply to the motor one close open operation shall be possible with the energy contained in the operating mechanism.

d) Breaker operation shall be independent of the motor which shall be used solely for compressing the closing spring. Facility for manual charging of the closing spring shall also be provided. The motor rating shall be such that it requires not more than 30 seconds for full charging of the closing spring.

e) Closing action of circuit breaker shall compress the opening spring ready for tripping.

f) When closing springs are discharged after closing a breaker, closing springs shall be automatically charged for the next operation and an indication of this shall be provided in the local and remote control cabinet.

g) Provisions shall be made to prevent a closing operation of the breaker when the spring is in the partial charged condition. Mechanical interlocks shall be provided in the operating mechanism to prevent discharging of closing springs when the breaker is already in the closed position.

h) The spring operating mechanism shall have adequate energy stored in the operating spring to close and latch the circuit breaker against the rated making current and also to provide the required energy for the tripping mechanism in case the tripping energy is derived from the operating mechanism.

9.0 SUPPORT STRUCTURE:

a) The structure design shall be such that during operation of circuit breaker vibrations are reduced to minimum.

10.0 TERMINAL CONNECTOR PAD:

The circuit breaker terminal pads shall be made up of high quality electrolytic copper or aluminium and shall be conforming to Australian standard AS-2935 for rated current. The terminal pad shall have protective covers which shall be removed before interconnections.

11.0 INTERPOLE CABLING:

11.1 All cables to be used by contractor shall be armoured and shall be as per IEC-502 (1100 Volts Grade). All cables within & between circuit breaker poles shall be supplied by the CB manufacturer.

11.2 Only stranded conductor shall be used. Minimum size of the conductor for interpole control wiring shall be 1.5 sq.mm. (Copper).

11.3 The cables shall be with oxygen index Min-29 and temp. index as 250^{o}C as per relevant standards.

12.0 FITTINGS AND ACCESSORIES

12.1 Following is a partial list of some of the major fittings and accessories to be furnished by Contractor in the Central Control cabinet. Number and exact location of these parts shall be indicated in the bid.

i) Cable glands (Double compression type), Lugs, Ferrules etc.

ii) Local/remote changeover switch.

iii) Operation Counter

iv) Control switches to cut off control power supply.

v) Fuses as required.

vi) The number of terminals provided shall be adequate enough to wire out all contacts and control circuits plus 24 terminals spare for future use.

vii) Antipumping relay.

viii) Pole discrepancy relay (for electrically ganged CBs).

ix) D.C. Supervision relays.

xi) Rating and diagram plate in accordance with IEC incorporating year of manufacture.

13.0 ADDITIONAL DATA TO BE FURNISHED:

a) Drawing, showing contacts in close, arc initiation, full arcing, arc extinction and open position.

b) The temperature v/s pressure curves for each setting of density monitor alongwith details of density monitor.

c) Data on capabilities of circuit breakers in terms of time and number of operations at duties ranging from 100% fault currents to load currents of the lowest possible value without requiring any maintenance or checks.

d) The effect of non-simultaneity between contacts between poles and also show how it is covered in the guaranteed total break time.

e) Sectional view of non-return couplings if used for SF6 pipes.

f) Details & type of filters used in interrupter assembly and also the operating experience with such filters.

g) Details of SF6 gas:

i) The test methods used in controlling the quality of gas used in the circuit breakers particularly purity and moisture content.

ii) Proposed tests to assess the conditions of the SF6 within a circuit breaker after a period of service particularly with regard to moisture contents of the gas.

h) All duty requirements as applicable to 245 kV & 145 kV CBs specified under Clause 2.0 of this Chapter shall be provided with the support of adequate test reports.

14.0 TESTS:

14.1 In accordance with the requirements stipulated under Chapter 2 -GTR the circuit breaker alongwith its operating mechanism shall conform to IEC:62271-100.

14.2 The test reports of the type tests and the following additional type tests shall also be submitted for Purchaser's review:

i) Out of phase closing test as per IEC:62271-100.

ii) Line charging breaking current for proving parameters as per clause no. 15.9 of this Chapter.

iii) Test to demonstrate the Power Frequency withstand capability of breaker in open condition at Zero Gauge pressure and at lockout pressure (Ref. Clause 4.1.1).

iv) Seismic withstand test in unpressurised condition.

v) Verification of the degree of protection.

vi) Static Terminal Load test.

vii) Critical Currents test (if applicable).

14.3 **Routine Tests**

Routine tests as per IEC:62271-100 shall be performed on all circuit breakers.

In addition to the mechanical and electrical tests specified by IEC, the following tests shall also be performed.

1) Speed curves for each breaker shall be obtained with the help of a suitable operation analyser to determine the breaker contact movement

during opening, closing, auto-reclosing and trip free operation under normal as well as limiting operating conditions (control voltage pressure etc.). The tests shall show the speed of contacts directly at various stages of operation, travel of contacts, opening time, closing time, shortest time between separation and meeting of contacts at break

make operation etc. This test shall also be performed at site for which the necessary operation analyser alongwith necessary transducers, cables, console, etc. where included in scope of supply shall be furnished and utilised. In case of substations where operation analyser is existing the bidder shall utilise the same. However necessary adopter and transducers etc. if required shall have to be supplied by the bidder.

2) Measurement of Dynamic Contact resistance measurement for arcing & main contacts. Signature of Dynamic contact resistance measurements shall be taken as reference for comparing the same during operation and maintenance in order to ascertain the healthiness of contacts.

15.0 TECHNICAL PARAMETERS:

(In addition to those indicated in Chapter 2 2-GTR)

A. 245 kV CIRCUIT BREAKER:

A15.1	Rated continuous current(A) at design ambient temperature.	1600/2500 (as applicable)
A15.2	Rated short circuit current breaking capacity at rated voltage	40 kA / 50 kA (as applicable) with percentage DC component as per IEC: 62271-100 corresponding to minimum opening time under operating conditions specified.
A15.3	Symmetrical interrupting capability (kArms)	40 / 50 (as applicable)
A15.4	Rated short circuit making current (kAp)	100 / 125 (as applicable)
A15.5	Short time current carrying capability for one second (kArms)	40 / 50 (as applicable)
A15.6	Rated operating duty	O-0.3sec-CO-3min-CO cycle
A15.7	Reclosing	Single phase & three phase autoreclosing

A15.8	First pole to clear factor	1.3
A15.9	Rated line/cable charging interrupting current at 90 deg. leading power factor angle (A. rms)	As per IEC

(The breaker shall be able to interrupt the rated line/cable charging current with test voltage immediately before opening equal to the product of U/□3 & 1.4 as per IEC: 62271-100).

A15.10	Temperature rise over the design ambient temperature	As per IEC: 62271-100
A15.11	i) Total break time as per Cl.3.0 of this Chapter (ms)	65
A15.11	ii) Rated break time as per IEC (ms)	60
A15.12	Total closing time (ms)	Not more than 200
A15.13	Operating mechanism	spring
A15.14	Max. difference in the instants of closing/ opening of contacts (ms)	
	i) Between poles (opening)	3.3
	ii) Between poles (closing)	5.0

The above shall be at rated control voltage and rated operating and quenching media pressures.

A15.15	Trip coil and closing coil voltage	220 V DC with variation as specified
A15.16	Noise level at base and upto 50 m (distance from base of breaker)	140 dB (Max.)
A15.17	Rated terminal load	As per IEC or as per the value calculated by Chapter 2-GTR, whichever is higher.

A15.18	Auxiliary contacts	Besides requirement of specification, the bidder shall wire up 5 NO + 5 NC contacts for future use of purchaser.
A15.19	No of Terminals in common Control cabinet	All Contacts & control circuits to be wired out upto common control cabinet plus 24 terminals exclusively for Purchaser's use.

B.	**145 kV CIRCUIT BREAKER:**	
B15.1	Rated continuous current(A) at design ambient temperature.	1250
B15.2	Rated short circuit current breaking capacity at rated voltage	31.5 kA with percentage DC component as per IEC: 62271-100 corresponding to minimum opening time under operating conditions specified
B15.3	Symmetrical interrupting capability (kA rms)	31.5
B15.4	Rated short circuit making current (kAp)	80
B15.5	Short time current carrying capability for one second (kA rms)	31.5
B15.6	Out of phase breaking current capacity (kA rms)	As per IEC
B15.6	Rated operating duty	O-0.3sec-CO-3min-CO cycle
B15.7	Reclosing	Single phase (for Line only) & three phase Autoreclosing
B15.8	First pole to clear factor	1.3
B15.9	Rated line/cable charging interrupting current at	As per IEC

	90 deg. leading power factor angle (A. rms)	
	(The breaker shall be able to interrupt the rated line/cable charging current with test voltage immediately before opening equal to the product of U/□3 & 1.4 as per IEC: 62271-100).	
B15.10	Temperature rise over the design ambient temperature	As per IEC: 62271-100
B15.11	i) Total break time as per Cl.3.0 of this Chapter (ms)	65
B15.11	ii) Rated break time as per IEC (ms)	60
B15.12	Total closing time (ms)	Not more than 150
B15.13	Operating mechanism	spring
B15.14	Max. difference in the instants of closing/ opening of contacts (ms) between poles at rated control voltage and rated operating and quenching media pressures.	3.3
B15.15	Trip coil and closing coil voltage	220 V DC with variation as specified
B15.16	Noise level at base and upto 50 m (distance from base of breaker)	140 dB (Max.)
B15.17	Rated terminal load	As per IEC or as per the value calculated by Chapter-GTR, whichever is higher.
B15.18	Auxiliary contacts	Besides requirement of specification, the bidder shall wire up 5 NO + 5 NC contacts for future use of Purchaser.
B15.19	No. of Terminals in common control cabinet	All contacts & control circuits to be wired out upto common control cabinet plus 24 terminals exclusively for Purchaser's use.

C. 72.5 kV CIRCUIT BREAKER

C15.1	Rated continuous current (A) at design ambient temperature.	1250/800 (as applicable)
C15.2	Rated short circuit current breaking capacity at rated voltage	25 kA with percentage DC component as per IEC: 62271-100 corresponding to minimum opening time under operating conditions specified
C15.3	Symmetrical interrupting capability (kA rms)	25
C15.4	Rated short circuit making current (kAp)	As per IEC
C15.5	Short time current carrying capability for one second (kA rms)	25
C15.6	Out of phase breaking current capacity (kA rms)	As per IEC
C15.6	Rated operating duty	O-0.3sec-CO-3min-CO cycle
C15.7	Reclosing	Single phase (for Line only) & three phase Autoreclosing
C15.8	First pole to clear factor	1.3
C15.9	Rated line/cable charging interrupting current at 90 deg. leading power factor angle (A. rms)	As per IEC

(The breaker shall be able to interrupt the rated line/cable charging current with test voltage immediately before opening equal to the product of U/√3 & 1.4 as per IEC: 62271-100).

C15.10	Temperature rise over the design ambient temperature	As per IEC: 62271-100

C15.11	i) Rated break time as per IEC (ms)	45
C15.12	Total closing time (ms)	Not more than 80
C15.13	Operating mechanism	spring
C15.14	Max. difference in the instants of closing/ opening of contacts (ms) between poles at rated control voltage and rated operating and quenching media pressures.	3.3
C15.15	Trip coil and closing coil voltage	220 V DC with variation as specified
C15.16	Noise level at base and upto 50 m (distance from base of breaker)	140 dB (Max.)
C15.17	Rated terminal load	As per IEC or as per the value calculated by Chapter-GTR, whichever is higher.
C15.18	Auxiliary contacts	Besides requirement of specification, the bidder shall wire up 5 NO + 5 NC contacts for future use of Purchaser.
C15.19	No. of Terminals in common control cabinet	All contacts & control circuits to be wired out upto common control cabinet plus 24 terminals exclusively for Purchaser's use.

D. 36 kV CIRCUIT BREAKER

D15.1	Rated continuous current(A) at design ambient temperature.	1250/800 (as applicable)
D15.2	Rated short circuit current breaking capacity at rated voltage	25 kA with percentage DC component as per IEC: 62271-100 corresponding to minimum opening time under operating conditions specified
D15.3	Symmetrical interrupting capability (kA rms)	25

D15.4	Rated short circuit making current (kAp)	As per IEC
D15.5	Short time current carrying capability for one second (kA rms)	25
D15.6	Out of phase breaking current capacity (kA rms)	As per IEC
D15.6	Rated operating duty	O-0.3sec-CO-3min-CO cycle
D15.7	Reclosing	Single phase (for Line only) & three phase Autoreclosing
D15.8	First pole to clear factor	1.3
D15.9	Rated line/cable charging interrupting current at 90 deg. leading power factor angle (A. rms)	As per IEC

(The breaker shall be able to interrupt the rated line/cable charging current with test voltage immediately before opening equal to the product of U/□3 & 1.4 as per IEC: 62271-100).

D15.10	Temperature rise over the design ambient temperature	As per IEC: 62271-100
D15.11	i) Rated break time as per IEC (ms)	45
D15.12	Total closing time (ms)	Not more than 80
D15.13	Operating mechanism	spring
D15.14	Max. difference in the instants of closing/ opening of contacts (ms) between poles at rated control voltage and rated operating and quenching media pressures.	3.3

D15.15	Trip coil and closing coil voltage	220 V DC with variation as specified
D15.16	Noise level at base and upto 50 m (distance from base of breaker)	140 dB (Max.)
D15.17	Rated terminal load	As per IEC or as per the value calculated by Chapter-GTR, whichever is higher.
D15.18	Auxiliary contacts	Besides requirement of specification, the bidder shall wire up 5 NO + 5 NC contacts for future use of Purchaser.
D15.19	No. of Terminals in common control cabinet	All contacts & control circuits to be wired out upto common control cabinet plus 24

16.0 PRE-COMMISSIONING TESTS

16.1 An indicative list of tests is given below. All routine tests except power frequency voltage dry withstand test on main circuit breaker shall be repeated on the completely assembled breaker at site. Contractor shall perform any additional test based on specialties of the items as per the field Q.P./instructions of the equipment Supplier or Employer without any extra cost to the Employer. The Contractor shall arrange all instruments required for conducting these tests along with calibration certificates and shall furnish the list of instruments to the Employer for approval.

(a) Insulation resistance of each pole.

(b) Check adjustments, if any suggested by manufacturer.

(c) Breaker closing and opening time.

(d) Slow and Power closing operation and opening.

(e) Trip free and anti pumping operation.

(f) Minimum pick-up voltage of coils.

(g) Dynamic Contact resistance measurement.

(h) Functional checking of control circuits interlocks, tripping through protective relays and auto reclose operation.

(i) Insulation resistance of control circuits, motor etc.

(j) Resistance of closing and tripping coils.

(k) SF6 gas leakage check.

(l) Dew Point Measurement

(m) Operation check of pressure switches and gas density monitor during gas filling.

(n) Checking of mechanical 'CLOSE' interlock, wherever applicable.

(o) Resistance measurement of main circuit.

(p) Checking of operating mechanisms

(q) Check for annunciations in control room.

16.2 The contractor shall ensure that erection, testing and commissioning of circuit breaker shall be carried out under the supervision of the circuit breaker manufacturer's representative. The commissioning report shall be signed by the manufacturers representative.

SECTION 2 – ISOLATORS

1.0 GENERAL:

1.1 The Isolators and accessories shall conform in general to IEC: 62271-102 except to the extent explicitly modified in specification and shall be in accordance with requirement of Chapter 2-GTR.

1.2 Isolators shall be outdoor, off-load type. Earth switches shall be provided on isolators wherever called for, with possibility of being mounted on any side of the isolator. 220 kV & below rated isolators shall be double break type, unless specified otherwise.

1.3 Complete isolator with all the necessary items for successful operation shall be supplied including but not limited to the following:

1.3.1 Isolator assembled with complete Support Insulators, operating rod insulator, base frame, linkages, operating mechanism, control cabinet, interlocks etc.

1.3.2 All necessary parts to provide a complete and operable isolator installation, control parts and other devices whether specifically called for herein or not.

1.3.3 The isolator shall be designed for use in the geographic and meteorological conditions as given in Chapter 2-GTR.

2.0 DUTY REQUIREMENTS:

a) Isolators and earth switches shall be capable of withstanding the dynamic and thermal effects of the maximum possible short circuit current of the systems in their closed position. They shall be constructed such that they do not open under influence of short circuit current.

b) The earth switches, wherever provided, shall be constructionally interlocked so that the earth switches can be operated only when the isolator is open and vice versa. The constructional interlocks shall be built in construction of isolator and shall be in addition to the electrical interlocks. Suitable mechanical arrangement shall also be provided for delinking electrical drive for manual operation.

c) In addition to the constructional interlock, isolator and earth switches shall have provision to prevent their electrical and manual operation unless the associated and other interlocking conditions are met. All these interlocks shall be of fail safe type. Suitable individual interlocking coil arrangements shall be provided. The interlocking coil shall be suitable for continuous operation from DC supply and within a variation range as stipulated in Chapter 2-GTR.

d) The earthing switches shall be capable of discharging trapped charges of the associated lines.

e) The isolator shall be capable of making/breaking normal currents when no significant change in voltage occurs across the terminals of each pole of isolator on account of make/break operation.

f) Isolator rated for above 72.5 kV shall be of extended mechanical endurance class - M2 as per IEC-62271-102. Isolator rated for 72.5 kV and below shall be of extended mechanical endurance class - M1 as per IEC-62271-102. All earth switches shall be of M0 duty**.**

3.0 CONSTRUCTIONAL FEATURES:

The features and constructional details of Double Break Isolators, earth switches and accessories shall be in accordance with requirements stated hereunder:

3.1 **Contacts:**

a) The contacts shall be self aligning and self cleaning and so designed that binding cannot occur after remaining closed for prolonged periods of time in a heavily polluted atmosphere.

b) No undue wear or scuffing shall be evident during the mechanical endurance tests. Contacts and spring shall be designed so that readjustments in contact pressure shall not be necessary throughout the life of the isolator or earthing switch. Each contact or pair of contacts shall be independently sprung so that full pressure is maintained on all contacts at all time.

c) Contact springs shall not carry any current and shall not loose their characteristics due to heating effects.

d) The moving contact of double break isolator shall have turn-and -twist type or other suitable type of locking arrangement to ensure adequate contact pressure.

viii) Base :

Each single pole of the isolator shall be provided with a complete galvanised steel base provided with holes and designed for mounting on a supporting structure.

ix) Blades :

a) All metal parts shall be of non-rusting and non-corroding material. All current carrying parts shall be made from high conductivity electrolytic copper/aluminium. Bolts, screws and pins shall be provided with lock washers. Keys or equivalent locking facilities if provided on current carrying parts, shall be made of copper silicon alloy or stainless steel or equivalent. The bolts or pins used in current carrying parts shall be made of non-corroding material. Ferrous parts, other than stainless steel shall not be used in close proximity of main current path. All ferrous castings, if used elsewhere shall be made of malleable cast iron or cast-steel. No grey iron shall be used in the manufacture of any part of the isolator.

b) The live parts shall be designed to eliminate sharp joints, edges and other corona producing surfaces, where this is impracticable adequate corona rings shall be provided. **Corona shields are not acceptable.** Corona rings shall be made up of aluminum/aluminum alloy.

c) Isolators and earthing switches including their operating parts shall be such that they cannot be dislodged from their open or closed positions by short circuit forces, gravity, wind pressure, vibrations, shocks, or accidental touching of the connecting rods of the operating mechanism.

d) The switch shall be designed such that no lubrication of any part is required except at very infrequent intervals. i.e. after every 1000 operations or after 5 years whichever is earlier.

x) Insulator :

a) The insulator shall conform to or IEC-60168. The porcelain of the insulator shall conform to the requirements stipulated under Chapter 2-GTR and shall have a minimum cantilever strength of **1000**/600 Kgs. for 245/145 kV insulators respectively.

b) Pressure due to the contact shall not be transferred to the insulators after the main blades are fully closed.

c) The parameters of the insulators shall meet the requirements specified under Chapter 2-GTR.

d) Insulator shall be type and routine tested as per IEC-60168**.**

e) For 245 kV Insulator: (For Isolator)

Top PCD	=	127 mm
No. of holes	=	4 x M16
Bottom PCD	=	**275 mm**
No. of holes	=	8 x 18 dia

9.0 For 145 kV Insulator: (For Isolator)

Top PCD	=	127 mm
No. of holes	=	4 x M16
Bottom PCD	=	254 mm
No. of holes	=	8 x 18 dia

xi) Name Plate :

The name plate shall conform to the requirements of IEC incorporating year of manufacture.

EARTHING SWITCHES :

a) Where earthing switches are specified these shall include the complete operating mechanism and auxiliary contacts.

b) The earthing switches shall form an integral part of the isolator and shall be mounted on the base frame of the isolator.

c) Earthing switches shall be only locally operated.

d) The earthing switches shall be constructionally interlocked with the isolator so that the earthing switches can be operated only when the isolator is open and vice versa. The constructional interlocks shall be built in construction of isolator and shall be in addition to the electrical interlocks. Suitable mechanical arrangement shall be provided for de-linking electrical drive for manual operation.

e) Each earth switch shall be provided with flexible copper/aluminum braids for connection to earth terminal. These braids shall have the same short time current carrying capacity as the earth blade. The transfer of fault current through swivel connection will not be accepted.

f) The plane of movement and final position of the earth blades shall be such that adequate electrical clearances are obtained from adjacent live parts in the course of its movement between ON and OFF position.

g) The frame of each isolator and earthing switches shall be provided with two reliable earth terminals for connection to the earth mat.

h) Isolator design shall be such as to permit addition of earth switches at a future date. It should be possible to interchange position of earth switch to either side.

i) The earth switch should be able to carry the same fault current as the main blades of the Isolators and shall withstand dynamic stresses.

j) 245 kV earth switches shall also comply with the requirements of IEC-62271-102, in respect of induced current switching duty as defined for Class-B and short circuit making capability class E-0 for earthing switches.

OPERATING MECHANISM :

a) The bidder shall offer motor operated Isolators and earth switches. Isolators of 36 kV and below and earth switches of 72.5 kV and below rating shall be manual operated.

b) Control cabinet/operating mechanism box shall conform to the requirement stipulated in Chapter 2-GTR and shall be made of cast aluminium/aluminum sheet of adequate thickness (minimum 3 mm) .

c) A "Local/Remote" selector switch and a set of open/ close push buttons shall be provided on the control cabinet of the isolator to permit its operation through local or remote push buttons.

d) Provision shall be made in the control cabinet to disconnect power supply to prevent local/remote power operation.

e) Motor shall be an AC motor and conform to the requirements of Chapter 2-GTR.

f) Suitable reduction gearing shall be provided between the motor and the drive shaft of the isolator. The mechanism shall stop immediately when motor supply is switched off. If necessary a quick electromechanical brake shall be fitted on the higher speed shaft to effect rapid braking.

g) Manual operation facility (with handle) should be provided with necessary interlock to disconnect motor.

h) Gear should be of forged material suitably chosen to avoid bending/jamming on operation after a prolonged period of non operation. Also all gear and connected material should be so chosen/surface treated to avoid rusting.

i) The test report for blocked rotor test of motor shall be submitted as per the requirement of clause 23.0 of Chapter 2: GTR of Technical Specification.

j) Only stranded conductor shall be used for wiring. Minimum size of the conductor for control circuit wiring shall be 1.5 sq.mm. (Copper).

k) The operating mechanism shall be located such that it can be directly mounted on any one of the support structure.

OPERATION :

a) The main Isolator and earth switches shall be gang operated in case of 245 kV, 145 kV, 72.5 kV & 36kV. However, 245 kV Tandem Isolators shall be individual-pole operated. The operating mechanism of the three poles shall be well synchronized and interlocked.

b) The design shall be such as to provide maximum reliability under all service conditions. All operating linkages carrying mechanical loads shall be designed for negligible deflection. The length of inter insulator and interpole operating rods shall be capable of adjustments, by means of screw thread which can be locked with a lock nut after an adjustment has been made. The isolator and earth switches shall be provided with "over center" device in the operating mechanism to prevent accidental opening by wind, vibration, short circuit forces or movement of the support structures.

c) Each isolator/pole of isolator and earthswitch shall be provided with a manual operating handle enabling one man to open or close the isolator with ease in one movement while standing at ground level. Non-detachable type manual operating handle shall have provision for padlocking. For detachable type manual operating handles, suitable provision shall be made inside the operating mechanism box for parking the detached handles. The provision of manual operation shall be located at a convenient operating height from the base of isolator support structure.

d) The isolator shall be provided with positive continuous control throughout the entire cycle of operation. The operating pipes and rods shall be sufficiently rigid to maintain positive control under the most adverse conditions and when operated in tension or compression for isolator closing. They shall also be capable of withstanding all torsional and bending stresses due to operation of the isolator. Wherever supported the operating rods shall be provided with bearings on either ends. The operating rods/ pipes shall be provided with suitable universal couplings to account for any angular misalignment.

e) All rotating parts shall be provided with grease packed roller or ball bearings in sealed housings designed to prevent the ingress of moisture, dirt or other foreign matter. Bearings pressure shall be kept low to ensure long life and ease of operation. Locking pins wherever used shall be rustproof.

f) Signaling of closed position shall not take place unless it is certain that the movable contacts, have reached a position in which rated normal current, peak withstand current and short time withstand current can be carried safely. Signaling of open position shall not take place unless movable contacts have reached a position such that clearance between contacts is atleast 80% of the isolating distance.

g) The position of movable contact system (main blades) of each of the Isolators and earthing switches shall be indicated by a mechanical indicator at the lower end of the vertical rod of shaft for the Isolators and earthing switch. The indicator shall be of metal and shall be visible from operating level.

h) The contractor shall furnish the following details alongwith quality norms, during detailed engineering stage.

(i) Current transfer arrangement from main blades of isolator alongwith milli volt drop immediately across transfer point.

(ii) Details to demonstrate smooth transfer of rotary motion from motor shaft to the insulator alongwith stoppers to prevent over travel.

7.0 TERMINAL CONNECTOR STUD/PAD:

The isolator terminal pads/studs shall be made of high quality copper or aluminium and shall be conforming to Australian standard AS-2935 for rated current. The terminal pad shall have protective covers, which shall be removed before interconnections.

8.0 SUPPORT STRUCTURE:

245 kV/145/72.5/36 kV Isolators shall be suitable for mounting on support structures to be supplied in accordance with stipulations of Chapter 2-GTR.

9.0 TESTS:

9.1 In continuation to the requirements stipulated under Chapter 2-GTR the isolator alongwith its earthing switch and operating mechanism should have been type tested as per IEC and shall be subjected to routine tests in accordance with IEC-62271-102. — Minimum 1000 Nos. mechanical operations in line with mechanical endurance test, M0 duty, shall be carried out on 1 (one) isolator out of every lot of Isolators, assembled completely with all accessories, as acceptance test for the lot. The travel characteristics measured at a suitable location in the base of insulator along with motor current/power drawn, during the entire travel duration are to be recorded at the start and completion and shall not vary by more than (+/-) 10% after completion of 1000 cycles of operation. After completion of test, mechanical interlock operation to be checked**.**

9.2 The test reports of the type tests and the following additional type tests (additional type tests are required for isolators rated above 72.5 kV only) shall also be submitted for the Purchaser's review.

(i) Radio interference voltage test.

9.1 Seismic withstand test on isolator mounted on Support structure. The test shall be performed in the following position :

Isolator open	E/S Closed
Isolator open	E/S Open
Isolator Closed	E/S Open

10.0 SPARE PARTS AND MAINTENANCE EQUIPMENT:

Bidder shall include in his proposal mandatory spare parts in accordance with the requirements stipulated in Chapter 1 - PSR.

11.0 TECHNICAL PARAMETERS:
(In addition to those specified under Chapter 2-GTR)

A.	**245 kV ISOLATORS:**	
A11.1	Type	Outdoor
A11.2	Rated current at 50^{o}C ambient temperature	1600A / 2500 A (As applicable).
A11.3	Rated short time withstand current of isolator and earth switch (for 1 Sec.)	40 kA/ 50 kA (as applicable)
A11.4	Rated dynamic short circuit withstand current of isolator and earth switch	100 kAp / 125 kAp (as applicable)
A11.5	Temperature rise over design ambient temperature	As per table V of IEC-694.
A11.6	Rated mechanical terminal load	As per table III of IEC-62271-102 or as per value calculated in Chapter 2-GTR whichever is higher.
A11.7	Operating mechanism of isolator/earth switch	A.C. Motor operated
A11.8	No. of auxiliary contacts on each isolator	Besides requirement of this spec., the bidder shall wire up 5 NO + 5 NC to TBs (Reversible) for Purchaser's future use.
A11.9	No. of auxiliary contacts on each earthing switch	Besides requirement of this spec., the bidder shall wire up 3 NO + 3 NC to TBs (Reversible) for Purchaser's future use.
A11.10	Operating time	15 sec. or less
A11.11	Number of terminal in control cabinet (Interpole cabling shall be supplied by Contractor)	All contacts & control circuits are to be wired upto control cabinet plus 24 spare terminals evenly distributed.
B.	**145 kV ISOLATORS:**	
B11.1	Type	Outdoor

B11.2	Rated current at 50^{o}C ambient temperature	1250 A
B11.3	Rated short time withstand current of isolator and earth switch	31.5 kA for 1 Sec.
B11.4	Rated dynamic short circuit withstand current of isolator and earth switch	80 kAp
B11.5	Temperature rise over design ambient temperature	As per table V of IEC-694.
B11.6	Rated mechanical terminal load.	As per table III of IEC-62271-102 or as per value calculated in Chapter 2-GTR whichever is higher.
B11.7	Operating mechanism of isolator/earth switch	A.C. Motor operated
B11.8	No. of auxiliary contacts on each isolator	Besides requirement of this spec., 5 NO + 5 NC to contacts, wired to terminal block exclusively for Purchaser's use in future.
B11.9	No. of auxiliary contacts on each earthing switch	Besides requirement of this spec., the bidder shall wire up 3 NO + 3 NC to TBs (Reversible) for Purchaser's future use.
B11.10	Operating time	15 sec. or less
B11.11	Number of terminal in control cabinet (Interpole cabling shall be supplied by Contractor)	All contacts & control circuits are to be wired upto control cabinet plus 24 spare terminals evenly distributed.

C. 72.5 kV ISOLATOR

C11.1	Type	Outdoor (Double Break)
C11.2	Temperature rise over design ambient temperature	As per table V of IEC 62271-1

C11.3	Rated mechanical terminal load	As per table-III of IEC 62271-102 IEC 129(1984) or as per value calculated in Chapter 2-GTR whichever is higher
C11.4	Number of terminals in control cabinet (Interpole cabling shall be Supplied by contractor)	All contacts and control circuits are to be wired upto control cabinet plus 24 terminals exclusively for Owner's use.
C11.5	Rated current at design ambient temperature	1250/800 Amps(as applicable).
C11.6	Rated short time withstand current of isolator and earthswitch	25 kA for 3 Sec
C11.7	Rated dynamic short circuit withstand current of isolator and earth switch	As per IEC
C11.8	Operating mechanism for Isolator and Earth switch	Manual
C11.9	No. of auxiliary contacts on each isolator	5 NO + 5 NC contacts, wired to terminal block exclusively for Owner's use in future.
C11.10	No. of auxiliary contacts on each earthing switch	3 NO + 3 NC contacts wired to terminal block exclusively for Owner's use in future.

C.I The porcelain of the 72.5 kV insulators shall have minimum cantilever strength of 450 Kgs

C.II 72.5 kV Isolator shall be gang operated for main blades and earth switches.

D. 36kV ISOLATOR

D11.1	Type	Outdoor (Double Break)
D11.2	Temperature rise over design ambient temperature	As per table V of IEC 62271-1
D11.3	Rated mechanical terminal load	As per table-III of IEC 62271-102

		IEC 129(1984) or as per value calculated in Chapter 2- GTR whichever is higher
D11.4	Number of terminals in control cabinet (Interpole cabling shall be Supplied by contractor)	All contacts and control circuits are to be wired upto control cabinet plus 24 terminals exclusively for Owner's use.
D11.5	Rated current at design ambient temperature	1250/800 Amps(as applicable).
D11.6	Rated short time withstand current of isolator and earthswitch	25 kA for 3 Sec
D11.7	Rated dynamic short circuit withstand current of isolator and earth switch	As per IEC
D11.8	Operating mechanism for Isolator and Earth switch	Manual
D11.9	No. of auxiliary contacts on each isolator	5 NO + 5 NC contacts, wired to terminal block exclusively for Owner's use in future.
D11.10	No. of auxiliary contacts on each earthing switch	3 NO + 3 NC contacts wired to terminal block exclusively for Owner's use in future.

D.I The porcelain of the 36 kV insulators shall have minimum cantilever strength of 450 KGS

D.II 36 kV Isolator shall be gang operated for main blades and earth switches.

12.0 PRE-COMMISSIONING TESTS

12.1 An indicative list of tests on isolator and earthswitch is given below. Contractor shall perform any additional test based on specialties of the items as per the field Q.P./instructions of the equipment Supplier or Purchaser without any extra cost to the Purchaser. The Contractor shall arrange all instruments required for conducting these tests alongwith calibration certificates and shall furnish the list of instruments to the Purchaser for approval.

(a) Insulation resistance of each pole.

(b) Manual and electrical operation and interlocks.

(c) Insulation resistance of control circuits and motors.

(d) Ground connections.

(e) Contact resistance.

(f) Proper alignment so as to minimize vibration during operation.

(g) Measurement of operating Torque for isolator and Earth switch.

(h) Resistance of operating and interlocks coils.

(i) Functional check of the control schematic and electrical & mechanical interlocks.

(j) 50 operations test on isolator and earth switch.

12. 2 The contractor shall ensure that erection, testing and commissioning of Isolators above 72.5 kV class shall be carried out under the supervision of the Isolator manufacturer's representative. The commissioning report shall be signed by the manufacturer's representative.

SECTION 3 - INSTRUMENT TRANSFORMERS

1.0 GENERAL:

1.1 The instrument transformers and accessories shall conform to the latest version of the standards specified below except to the extent explicitly modified in the specification and shall be in accordance with the requirements in Chapter 2-GTR.

Current Transformers IEC: 60044-1

Capacitive Voltage Transformers IEC:60044-5 / IEC-60358

Inductive Voltage Transformers IEC:60044-2

1.2 The instrument transformers shall be complete with its terminal box and a common marshalling box for a set of 3 instrument transformers.

1.3 The external surface of instrument transformer, if made of steel, shall be hot dip galvanized or painted as per **Chapter 2-GTR.**

1.4 The impregnation details alongwith tests/checks to ensure successful completion of impregnation cycle shall be furnished for approval.

1.5 The instrument transformers shall be designed for use in geographic and meteorological conditions as given in Chapter 2-GTR.

2.0 CONSTRUCTION FEATURES:

The features and constructional details of instrument transformers shall be in accordance with requirements stipulated hereunder:

2.1 a) Instrument transformers shall be of 420/245/145 kV class, oil filled/ SF6 gas filled, suitable for outdoor service and upright mounting on steel structures. 245/145 kV Instrument transformers shall be with shedded porcelain/ polymer bushings/Insulators

b) Bushings/Insulators shall conform to requirements stipulated in Section-GTR. The bushing/insulator for CT shall be one piece without any metallic flange joint.

c) Oil filling and drain plugs, oil sight glass shall be provided for CT and for electromagnetic unit of CVT etc. The Instrument transformer shall have cantilever strength of not less than 500 kg, 350 kg and 350 kg **respectively for** 420 kV, 245kV and 145 kV Instrument transformers. For CVT with polymer housing, the cantilever strength shall not be less than 150kg. Oil filling and drain plugs are not required with SF6 gas filled CT.

d) Instruments transformers shall be hermetically sealed units. Bidder/ Manufacturer shall furnish details of the arrangements made for the sealing of instrument transformers *during detailed engineering*.

Bidder/Manufacturer shall also furnish the details of site tests to check the effectiveness of hermetic sealing for approval.

e) Polarity marks shall indelibly be marked on each instrument transformer and at the lead terminals at the associated terminal block.

f) In case of SF_6 filled CTs/Inductive VTs, it shall be provided with a suitable SF_6 gas density monitoring device, with NO/NC contacts to facilitate the remote annunciation and tripping in case of SF_6 leakage. Provisions shall be made for online gas filling. Suitable rupture disc shall be provided to prevent explosion.

2.2 **Terminal box/Marshalling Box:**

Terminal box shall conform to the requirements of Chapter 2-GTR.

2.3 **Insulating Oil:**

a) Insulating oil to be used for instrument transformers shall be of EHV grade and shall conform to IEC - 60296 (required for first filling). Non–PCB based synthetic insulating oil conforming to IEC 60867 can also be used in the capacitor units of CVT with specific approval from the owner, the proposal for which shall be submitted during detailed engineering stage.

b) The SF6 gas shall comply with IEC-60376, 60376A and 60376B and shall be suitable in all respects for use in the switchgear under operating conditions.

2.4 **Name Plate:**

Name plate shall conform to the requirements of IEC incorporating the year of manufacture. The rated current, extended current rating in case of current transformers and rated voltage, voltage factor in case of voltage transformers shall be clearly indicated on the name plate. The rated thermal current in case of CT shall also be marked on the name plate.

The intermediate voltage in case of capacitor voltage transformer shall be indicated on the name plate.

3.0 CURRENT TRANSFORMERS:

a) Current transformers shall have single primary either ring type, or hair pin type and suitably designed for bringing out the secondary terminals in a weather proof (IP 55) terminal box at the bottom. PF Terminal for measurement of tan delta and capacitance of the unit shall be provided. These secondary terminals shall be terminated to stud type non disconnecting terminal blocks inside the terminal box. In case "Bar primary" inverted type current transformers are offered the manufacturer will meet following additional requirements:

(i) The secondaries shall be totally encased in metallic shielding providing a uniform equipotential surface for even electric field distribution.

(ii) The lowest part of the insulation assembly shall be properly secured to avoid any risk of damage due to transportation stresses.

(iii) The upper part of insulation assembly resting on primary bar shall be properly secured to avoid any damage during transportation due to relative movement between insulation assembly & top dome.

(iv) Nitrogen if used for hermetic sealing (in case of live tank design) should not come in direct contact with oil.

(v) Bidder/Manufacturer shall recommend whether any special storage facility is required for spare CT.

b) Different ratios specified shall be achieved by secondary taps only and primary reconnection shall not be accepted.

c) Core lamination shall be of cold rolled grain oriented silicon steel or other equivalent alloys. The cores used for protection shall produce undistorted secondary current under transient conditions at all ratios with specified CT parameters.

d) The expansion chamber at the top of the porcelain insulators should be suitable for expansion of oil.

e) Facilities shall be provided at terminal blocks in the marshalling box for star delta formation, short circuiting and grounding of CT secondary terminals.

f) Current transformer's guaranteed burdens and accuracy class are to be intended as simultaneous for all cores.

g) For 245/145 kV class CTs, the rated extended primary current shall be 120% (or 150% if applicable) on all cores of the CTs as specified in the Chapter 1 – PSR.

h) For 420/245/145 kV current transformer, characteristics shall be such as to provide satisfactory performance of burdens ranging from 25% to 100% of rated burden over a range of 5% to 120%(or specified rated extended current whichever is higher) of rated current in case of metering CTs and up to the accuracy limit factor/knee point voltage in case of relaying CTs.

i) The current transformer shall be suitable for horizontal transportation. It shall be ensured that the CT is able to withstand all the stresses imposed on it while transporting and there shall be no damage in transit. The Contractor shall submit the details of packing design to the Purchaser for review.

j) For 400/245/145 kV CTs the instrument security factor at all ratios shall be less than five (5) for metering core. If any auxiliary CTs/reactor are used in the current transformers then all parameters specified shall have to be met treating auxiliary CTs as an integral part of the current transformer. The auxiliary CTs/reactor shall preferably be inbuilt construction of the CTs. In case these are to be mounted separately these shall be mounted in the central marshalling box suitably wired upto the terminal blocks.

k) The wiring diagram plate for the interconnections of the three single phase CTs shall be provided inside the marshalling box.

l) The current transformers should be suitable for mounting on lattice support structure or pipe structure to be provided by the Contractor in accordance with stipulations of Chapter 2-GTR.

m) The CT shall be so designed as to achieve the minimum risks of explosion in service. Bidder/Manufacturer shall bring out in his offer, the measures taken to achieve this.

n) 420/245/145 kV current transformers shall be suitable for high speed auto reclosing.

4.0 VOLTAGE TRANSFORMERS:

a) 420/245/145 kV Voltage transformers shall be capacitor voltage divider type with electromagnetic units and shall be suitable for carrier coupling. 72.5 kV Voltage transformers shall be capacitor voltage divider or Inductive Type and 36kV Voltage transformers shall be Inductive Type.

b) Voltage transformers secondaries shall be protected by HRC cartridge type fuses for all the windings. In addition fuses shall be provided for the protection and metering windings for fuse monitoring scheme. The secondary terminals of the VTs shall be terminated to the stud type non - disconnecting terminal blocks in the individual phase secondary boxes via the fuse.

c) VTs shall be suitable for high frequency (HF) coupling required for power line carrier communication. Carrier signal must be prevented from flowing into potential transformer (EMU) circuit by means of a RF choke/reactor suitable for effectively blocking the carrier signals over the entire carrier frequency range i.e. 40 to 500 KHz. Details of the arrangement shall be furnished along with the bid. H.F. terminal of the VT shall be brought out through a suitable bushing and shall be easily accessible for connection to the coupling filters of the carrier communication equipment, when utilised. Further, earthing link with fastener to be provided for HF terminal.

d) The electromagnetic unit comprising compensating reactor, intermediate transformer and protective and damping devices should have separate terminal box with all the secondary terminals brought out.

e) The damping device, which should be permanently connected to one of the secondary windings, should be capable of suppressing the ferroresonance oscillations.

f) The accuracy of 0.2 on secondary III for all VTs should be maintained through out the entire burden range upto 50 VA on all the windings without any adjustments during operation.

g) 420/245/145 kV VTs shall be suitable for mounting on tubular GI pipe in accordance with stipulations of Chapter 2-GTR.

h) It should be ensured that access to secondary terminals is without any danger of access to high voltage circuit.

i) A protective surge arrester shall be provided *if required*, to prevent breakdown of insulation by incoming surges and to limit abnormal rise of terminal voltage of shunt capacitor/primary winding, tuning reactor/RF choke etc. due to short circuit in transformer secondaries. In case of an alternate arrangement, bidder shall bring out the details in the bid.

j) The wiring diagram for the interconnection of the three single phase CVTs shall be provided inside the marshalling box in such a manner that it does not deteriorate with time. *A typical wiring diagram no. : 0000-000-T-E-L-029 is enclosed herewith to be followed by the Bidder/Manufacturer.*

5.0 TERMINAL CONNECTORS:

The terminal connectors shall meet the requirements as given in Chapter 2-GTR.

6.0 TESTS:

6.1 In accordance with the requirements in Section-GTR, Current and Voltage Transformers should have been type tested and shall be subjected to routine tests in accordance with IEC:60044-1 and IEC: 60044-5/60044-2 respectively.

6.2 The test reports of the type tests and the following additional type tests (additional type tests are required for Instrument Transformers, rated above 72.5 kV only) shall also be submitted for the Purchaser's review.

a) **Current Transformers:**

i) Radio interference voltage test as per IEC 60044-1.

ii) Seismic withstand test.

iii) Thermal stability test, i.e. application of rated voltage and rated extended thermal current simultaneously by synthetic test circuit. (not applicable for SF6 filled CT)

iv) Thermal co-efficient test i.e. measurement of tan delta as a function of temperature (at ambient and between 80^{o}C & 90^{o}C) and voltage (at 0.3, 0.7, 1.0 and 1.1 Um/□3) (not applicable for SF6 filled CT)

v) The current transformer shall be subjected to Multiple chopped impulse test (not applicable for SF6 filled CT) by any one of the following two methods given below to assess the CT performance in service to withstand the high frequency over voltage generated due to closing & opening operation of isolators. Alternatively, method as per IEC:60044-1 may be followed:

***Method I**: 600 negative polarity lightning impulses chopped on crest will be applied to current transformer. The opposite polarity amplitude must be limited to 50% of crest value when the wave is chopped. One impulse per minute shall be applied and every 50 impulse high frequency currents form the windings and total current to earth will be recorded and be compared with reference currents recorded applying one or more (max 20) reduced chopped impulses of 50% of test value.*

Oil samples will be taken before and 3 days after the test. Gas analysis must not show appreciable rate of increase in various gases related with the results of the analysis performed before test.

Total sum of crest values of current through secondaries must not exceed 5% of the crest value of total current to earth.

CT must withstand dielectric tests after this test to pass the test.

***Method II**: 100 negative polarity impulses with a rise and fall time of less than 0.25 microsecond corrected to atmospheric condition shall be applied at one minute interval and total current through insulation of earth will be recorded. The amplitude of first opposite polarity should be limited to 50% of the chopped impulse crest value. Voltage and total current wave shapes shall be recorded after every 10 impulses, and will be compared with reference wave shapes recorded before test at 50% of test values.*

Oil sample shall be taken before and 3 days after the test and CT shall be deemed to have passed the test if the increase in gas content before and after test is not appreciable.

b) **Voltage transformers:**

i) High frequency capacitance and equivalent series resistance measurement (as per IEC-60358) for CVT.

ii) Seismic withstand test.

iii) Stray capacitance and stray conductance measurement of the low voltage terminal (as per IEC-60358) for CVT.

iv) Determination of temperature coefficient test (as per IEC-60358).

Radio interference voltage test as per IEC-60044-5/IEC-60044-2. However the RIV level shall be as specified in clause Major Technical Parameters in Section-GTR.

Apart from the above, report of all special tests mentioned in IEC-60044-5 for Capacitive voltage transformer shall also be submitted for approval.

6.3 The current and voltage transformer shall be subjected to the following routine tests in addition to routine tests as per IEC.

a) **CURRENT TRANSFORMERS:**

ROUTINE TESTS:

<u>for Oil filled CTs</u>

i) Measurement of Capacitance.

ii) Oil leakage test.

iii) Measurement of tan delta at 0.3, 0.7, 1.0 and 1.1 Um/□3.

<u>for SF6 filled CTs</u>

i) Dew point measurement

ii) SF6 alarm/ lockout check.

iii) SF6 leakage test. Gas leakage rate shall be maintained within 0.2% per annum.

b) **VOLTAGE TRANSFORMERS:**

Routine tests on Capacitive voltage transformer shall be done in line with IEC-60044-5.

7.0 SPARE PARTS AND MAINTENANCE EQUIPMENT:

The Bidder shall include in his proposal spare parts equipment in accordance with Section-Project.

8.0 TECHNICAL PARAMETERS:

8.1. CURRENT TRANSFORMER

A. 245 kV CURRENT TRANSFORMERS:

A8.1	Rated Primary current	1600 A
A8.2	Rated short time thermal current	40 kA for 1 sec/50 kA for 1 sec. (as applicable)
A8.3	Rated dynamic current kA (peak)	100 / 125 (as applicable)
A8.4	Maximum temperature rise over design ambient temperature	As per IEC:60044-1
A8.5	One minute power frequency withstand voltage sec. terminal & earth	5 kV
A8.6	Number of terminals	All terminals of control circuits are to be wired upto marshaling box plus 20% spare terminals evenly distributed on all TBs.
A8.7	Type of insulation	Class A

Current transformers shall also comply with requirements of Table - IIA.

B. 145 kV CURRENT TRANSFORMERS:

B8.1	Rated Primary current	-1250A -
B8.2	Rated short time thermal current	31.5 kA for 1 sec.
B8.3	Rated dynamic current	80 kA (peak)
B8.4	Maximum temperature rise over design ambient temperature	As per IEC:60044-1
B8.5	One minute power frequency withstand voltage sec. terminal & earth	5 kV
B8.6	Number of terminals	All terminals of control circuits are to be wired upto marshaling box plus 20% spare terminals evenly distributed on all TBs.
B8.7	Type of insulation	Class A

Current transformers shall also comply with requirements of Table – IIB/ or IIC as applicable.

C. 72.5 kV CURRENT TRANSFORMERS:

C8.1	Rated Primary current -	600/1200A(as applicable)
C8.2	Rated Extended Primary current	120% (on all cores)
C8.3	Rated short time thermal Current	25 kA for 3 sec.
C8.4	Rated dynamic current	As per IEC
C8.5.	Maximum temperature rise over design ambient Temperature	As per IEC:44-1
C8.6.	One minute power frequency with stand voltage sec. terminal & earth	5 kV
C8.7	Number of terminals	All terminals of control circuits are to be wired upto marshaling box plus 20% spare terminals evenly distributed on all TBs.
C8.8	Type of insulation	Class A

Current transformers shall also comply with requirements of Table I/D as applicable.

D. 36 kV CURRENT TRANSFORMERS:

D8.1	Rated Primary current -	600/1200A(as applicable)
D8.2	Rated Extended Primary current	120% (on all cores)
D8.3	Rated short time thermal Current	25 kA for 3 sec.
D8.4	Rated dynamic current	As per IEC
D8.5.	Maximum temperature rise over design ambient Temperature	As per IEC:44-1

D8.6.	One minute power frequency with stand voltage sec. terminal & earth	5 kV
D8.7	Number of terminals	All terminals of control circuits are to be wired upto marshaling box plus 20% spare terminals evenly distributed on all TBs.
D8.8	Type of insulation	Class A

Current transformers shall also comply with requirements of Table IID/IIE as applicable.

8.2. VOLTAGE TRANSFORMER

A. 420 KV VOLTAGE TRANSFORMERS:

A8.1	System fault level (for 1 second)	40 kA / 50 kA (as applicable)
A8.2	Standard reference range of frequencies for which the accuracies are valid	96% to 102% for protection and 99% to 101% for measurement
A8.3	High frequency capacitance entire carrier frequency range	Within 80% to 150% of ratedfor capacitance **(for CVT only)**
A8.4	Equivalent series resistance over the entire carrier frequency range	Less than 40 ohms **(for CVT only)**
A8.5	Stray capacitance and stray conductance of the LV terminal over entire carrier frequency range	As per IEC:358 **(for CVT only)**

A8.6 One minute power frequency withstand voltage:

i)	Between LV (HF) terminal and earth terminal	10 kV (rms) for exposed terminals and 4 KV (rms) for terminals enclosed in a weather proof box
ii)	For secondary winding	3 kV (rms)

A8.7	Maximum temperature rise over design ambient temperature	As per IEC:60044-2 or 60044-5
A8.8	Number of terminals in control cabinet (interpole cabling is to be supplied by Purchaser)	All terminals are wired upto marshaling box plus 12 terminals exclusively for Purchaser's use.
A8.9	Rated Total Thermal burden (VA)	300 (100VA/winding)

Voltage Transformers shall also comply with the requirements of Table-I/A of this Section.

B. 245 KV VOLTAGE TRANSFORMERS:

B8.1	System fault level (for 1 second)	40 kA / 50 kA (as applicable)
B8.2	Standard reference range of frequencies for which the accuracies are valid	96% to 102% for protection and 99% to 101% for measurement
B8.3	High frequency capacitance entire carrier frequency range	Within 80% to 150% of ratedfor capacitance **(for CVT only)**
B8.4	Equivalent series resistance over the entire carrier frequency range	Less than 40 ohms **(for CVT only)**
B8.5	Stray capacitance and stray conductance of the LV terminal over entire carrier frequency range	As per IEC:358 **(for CVT only)**
B8.6	One minute power frequency withstand voltage:	
	i) Between LV (HF) terminal and earth terminal	10 kV (rms) for exposed terminals and 4 KV (rms) for terminals enclosed in a weather proof box
	ii) For secondary winding	3 kV (rms)
B8.7	Maximum temperature rise over design ambient temperature	As per IEC:60044-2 or 60044-5

B8.8	Number of terminals in control cabinet (interpole cabling is to be supplied by Purchaser)	All terminals are wired upto marshaling box plus 12 terminals exclusively for Purchaser's use.
B8.9	Rated Total Thermal burden (VA)	300 (100VA/winding)

Voltage Transformers shall also comply with the requirements of Table-IA of this Section.

C. 145 KV VOLTAGE TRANSFORMERS:

C8.1	System fault level	31.5 kA for 1 second
C8.2	Standard reference range of frequencies for which the accuracies are valid	96% to 102% for protection and 99% to 101% for measurement
C8.3	High frequency capacitance for entire carrier frequency range	Within 80% to 150% of rated capacitance **(for CVT only)**
C8.4	Equivalent series resistance over the entire carrier frequency range	Less than 40 ohms **(for CVT only)**
C8.5	Stray capacitance and stray conductance of the LV terminal over entire carrier frequency range	As per IEC:358 **(for CVT only)**
C8.6	One minute power frequency withstand voltage:	
	i) Between LV (HF) terminal and earth terminal	10 kV (rms) for exposed terminals and 4 KV (rms) for terminals enclosed in a weather proof box
	ii) For secondary winding	3 kV (rms)
C8.7	Maximum temperature rise over design ambient temperature	As per IEC:60044-2 or 60044-5
C8.8	Number of terminals in control cabinet (interpole pole cabling is to be supplied by Purchaser)	All terminals are wired upto marshaling box plus 12 terminals exclusively for Purchaser's use.

C8.9	Rated Total Thermal burden (VA)	300 (100VA/winding)

Voltage Transformers shall also comply with the requirements of Table-IB of this Section.

D. 72.5 kV POTENTIAL TRANSFORMERS

D8.1	**System Fault level**	25kA for 3 sec
D8.2	Standard reference range of frequencies for which the Accuracies are valid	96% to 102% for protection and 99% to 102% for measurement
D8.3	One minute power frequency Withstand voltage:	
	i) Between LV terminal and earth earth terminal	10kVrms for exposed terminals and 4kVrms for terminals enclosed in a weather proof box.
	ii) For secondary winding	2 kVrms
D8.4	Maximum temperature rise over design ambient temperature	As per IEC 186
F8.5	Number of terminals in control Cabinet	All terminals of control circuits are wired upto marshalling box Plus spare 20% terminals evenly distributed on all TBs
D8.6	Rated total thermal burden	75 VA

Voltage Transformers shall also comply with the requirements of Table-I/C of this Section

E. 33 kV POTENTIAL TRANSFORMERS

E8.1	**System Fault level**	25kA for 3 sec
E8.2	Standard reference range of frequencies for which the Accuracies are valid	96% to 102% for protection and 99% to 102% for measurement
E8.3	One minute power frequency Withstand voltage:	
	i) Between LV terminal and earth	10kVrms for exposed terminals and

	earth terminal	4kVrms for terminals enclosed in a weather proof box.
	ii) For secondarywinding	2 kVrms
E8.4	Maximum temperature rise over design ambient temperature	As per IEC 186
E8.5	Number of terminals in control Cabinet	All terminals of control circuits are wired upto marshalling box Plus spare 20% terminals evenly distributed on all TBs
E8.6	Rated total thermal burden	75 VA

Voltage Transformers shall also comply with the requirements of Table-IC of this Section

9.0 PRE-COMMISSIONING TESTS

9.1 An indicative list of tests is given below. Contractor shall perform any additional test based on specialties of the items as per the field Q.P./Instructions of the equipment Supplier or Purchaser without any extra cost to the Purchaser. The Contractor shall arrange all instruments required for conducting these tests alongwith calibration certificates and shall furnish the list of instruments to the Purchaser for approval.

9.2 **Current Transformers**

(a) Insulation Resistance Test for primary and secondary.

(b) Polarity test

(c) Ratio identification test - checking of all ratios on all cores by primary injection of current.

(d) Dielectric test of oil (wherever applicable).

(e) Magnetizing characteristics test.

(f) Tan delta and capacitance measurement

xii) Secondary winding resistance measurement

(h) Contact resistance measurement (wherever possible/accessible).

(i) Test for SF6 (for SF6 filled CTs) – Dew point measurement, SF6 alarm/ lockout check.

(j) DGA test of oil.

Dissolved gas analysis to be carried out at the time of commissioning. CTs must have adequate provision for taking oil samples from the bottom of the CT without exposure to atmosphere. Bidder/Manufacturer shall recommend the frequency at which oil samples should be taken and norms for various gases in oil after being in operation for different durations. Bidder/Manufacturer should also indicate the total quantity of oil which can be withdrawn from CT for gas analysis before refilling or further treatment of CT becomes necessary.

9.3 **Voltage Transformers/Capacitive Voltage Transformers**

(a) Insulation Resistance test for primary (if applicable) and secondary winding.

(b) Polarity test

(c) Ratio test

(d) Dielectric test of oil (wherever applicable).

(e) Tan delta and capacitance measurement of individual capacitor stacks.

(f) Secondary winding resistance measurement.

TABLE – I/A

REQUIREMENTS OF 420 KV CAPACITIVE VOLTAGE TRANSFORMERS

S.No.	PARTICULAR			
1.	Rated primary voltage (kV rms)	420		
2.	Type	Single phase capacitor VT		
3.	No. of secondaries	3		
4.	Rated voltage factor	1.2 continuous 1.5 - 30 seconds		
5.	Phase angle error	± 10 minutes (For metering core)		
6.	Capacitance (pf)	4400/8800 (As applicable)	+ 10% - 5%	
		Secon-dary I	Secon-dary II	Secon-dary III
7.	Voltage Ratio 220/0.11	400/0.11	400/0.11	400/0.11
8.	Application	Protec-tion	Protec-tion	Meter-ing
9.	Accuracy	3 P	3 P	0.2
10.	Output burden (VA) (minimum)	50	50	50

TABLE - IB

REQUIREMENTS OF 245 KV CAPACITIVE VOLTAGE TRANSFORMERS

S.No.	PARTICULAR			
1.	Rated primary voltage (kV rms)	245		
2.	Type	Single phase capacitor VT		
3.	No. of secondaries	3		
4.	Rated voltage factor	1.2 continuous 1.5 - 30 seconds		
5.	Phase angle error	$\pm$ 10 minutes (For metering core)		
6.	Capacitance (pf)	4400/8800 (As applicable)	+ 10% - 5%	
		Secon-dary I	Secon-dary II	Secon-dary III
7.	Voltage Ratio	220/0.11	220/0.11	220/0.11
8.	Application	Protec-tion	Protec-tion	Meter-ing
9.	Accuracy	3 P	3 P	0.2
10.	Output burden (VA) (minimum)	50	50	50

TABLE - IC

REQUIREMENTS OF 145 KV CAPACITIVE VOLTAGE TRANSFORMERS

S.No.	PARTICULAR			
1.	Rated primary voltage (kV rms)	145		
2.	Type	Single phase capacitor VT		
3.	No. of secondaries	3		
4.	Rated voltage factor	1.2 continuous		
		1.5 - 30 seconds		
5.	Phase angle error	$\pm$ 10 minutes (For metering core)		
6.	Capacitance (pf)	8800		+ 10%/-5%
		Secon-dary I	Secon-dary II	Secon-dary III
7.	Voltage Ratio	132/0.11	132/0.11	132/0.11
8.	Application	Protec-tion	Protec-tion	Meter-ing
9.	Accuracy	3 P	3 P	0.2
10.	Output burden (VA) (minimum)	50	50	50

TABLE- ID

Requirements of 72.5 kV Voltage transformer

S.No.	PARTICULAR		
1.	Rated primary voltage (kV rms)	72.5	
2.	Type	Single phase Electro-magnetic or Capacitive VT	
3.	No. of secondaries	2	
4.	Rated Voltage Factor	1.2 continuous 1.5 – 30 seconds	
5.	Phase angle error	+ 20 minutes (For metering core)	
		Secondary I	Secondary II
6.	Voltage ratio	33/_/3 / 0.11/_/3	33/_/3 / 0.11/_/3
7.	Application	Protection	Metering
8.	Accuracy	5P	0.5
9.	Output Burden (VA) (minimum)	10	10

TABLE- IE

REQUIREMENTS OF 33 KV POTENTIAL TRANSFORMERS

S.No.	PARTICULAR			
1.	Rated primary voltage (kV rms)	36		
2.	Type	Single phase PT		
3.	No. of secondaries	3		
4.	Rated voltage factor	1.2 continuous 1.5 - 30 seconds		
5.	Phase angle error	+/- 20 minutes (for metering core)		
6.	Standard reference range of frequencies for which the Accuracies are valid	96% to 102% for protection and 99% to 102% for measurement		
7.	One minute power frequency Withstand voltage:			
	i) Between LV terminal and earth earth terminal	10kVrms for exposed terminals and 4kVrms for terminals enclosed in a weather proof box.		
	ii) For secondarywinding	2 kVrms		
8.	Maximum temperature rise over design ambient temperature	As per IEC 186		
9.	Number of terminals in control Cabinet	All terminals of control circuits are wired upto marshalling box Plus spare 20% terminals evenly distributed on all TBs		
10.	Rated total thermal burden	75 VA		
		Secon-dary I	Secon-dary II	Secon-daryIII
11.	.Voltage Ratio	33/0.11	33/0.11	33/0.11
12.	Application	Protec-tion	Protec-tion	Meter-ing
13.	Accuracy	3 P	3 P	0.5
14.	Output burden (VA) (minimum)	50	50	25

TABLE - IIA

REQUIREMENTS FOR 245 KV CURRENT TRANSFORMERS

No.of Cores	Core No.	Application	Current ratio	Output burden (VA)	Accuracy class as per IEC: 44-1	Min. knee pt.voltage (Vk)	Max. CT sec.wdg. resistance(ohms)	Max. Excitation current at Vk (in mA)
5	1	BUS DIFF CHECK	1600-800/1	-	-	1600/ 800	8/4	25 on 1600/1 Tap; 50 on 800/1 Tap
	2	BUS DIFF MAIN	1600-800/1	-	-	1600/ 800	8/4	25 on 1600/1 Tap; 50 on 800/1 Tap
	3	METERING	1600-800/1	20	**0.2S**	-	-	-
	4	TRANS. BACK UP/LINE PROTN.	1600-800/1	-	-	1600/ 800	8/4	25 on 1600/1 Tap; 50 on 800/1 Tap
	5	TRANS. DIFF/LINE PROTN	1600-800/1	-	-	1600/ 800	8/4	25 on 1600/1 Tap; 50 on 800/1 Tap

All relaying CTs shall be of accuracy class TPS as per IEC 60044-1

TABLE – IIB

REQUIREMENTS FOR 145 KV CURRENT TRANSFORMERS

No.of Cores	Core No.	Appli-cation	Current ratio	Output burden (VA)	Accuracy class as per IEC: 44-1	Min. knee pt.volt-age Vk	Max. CT sec.wdg. resist-ance(ohms)	Max. Excit-ation cur-rent at Vk (in mA)
5	1	BUS DIFF CHECK	800-400/1	-	-	800/400	8/4	25 on 800/1 Tap; 50 on 400/1 Tap
	2	BUS DIFF MAIN	800-400/1	-	-	800/400	8/4	25 on 800/1 Tap; 50 on 400/1 Tap
	3	METERING	800-400/1	20	**0.2S**	-	-	-
	4	TRANS. BACK UP/LINE PROTN.	800-400/1	-	-	800/400	8/4	25 on 800/1 Tap; 50 on 400/1 Tap
	5	TRANS. DIFF/LINE PROTN	800-400/1	-	-	800/400	8/4	25 on 800/1 Tap; 50 on 400/1 Tap

All relaying CTs shall be of accuracy class TPS as per IEC 60044-1

TABLE – IIC

REQUIREMENTS FOR 72.5 kV CURRENT TRANSFORMER

No. of Cores	Core No.	Application	Current Ratio	Output burden (VA)	Accuracy class & AL as per IEC 44-1	Remarks
2	1	O/C & E/F	50/1	10	5P10	
	2	Metering	50/1	10	0.5	

TABLE – IID
REQUIREMENTS FOR 33 kV CURRENT TRANSFORMERS
Current Transformer (600A)

No.of Cores	Core No.	Appli-cation	Current ratio	Output burden(VA)	Accuracy class as per IEC: 44-1	Min. knee pt.volt-age Vk	Max.CT sec.wdg. resis-ance(ohms)	Max.Excit-ation cur-rent at Vk (in mA)	Remarks
3	1	O/C & E/F	400-200/1	-	T.P.S.	600/ 300	4/2	40 on 400/1 Tap; 80 on 200/1 Tap	
	2	METERING	400-200-100/1	20	0.2	-	-	-	

All relaying CTs shall be of accuracy class PS as per IEC 60044-1.

TABLE – IIE
REQUIREMENTS FOR 33 kV CURRENT TRANSFORMERS
Current Transformer (1200A)

No.of Cores	Core No.	Appli-cation	Current ratio	Output burden(VA)	Accuracy class as per IEC: 44-1	Min. knee pt.volt-age Vk	Max.CT sec.wdg. resis-ance(ohms)	Max.Excit-ation cur-rent at Vk (in mA)	Remarks
3	1	O/C & E/F	1200-600/1	-	T.P.S.	1200/ 600	12/ 6	30 on 1200/1 Tap; 60 on 600/1 Tap	
	2	METERING	1200-600-	30	0.2	-	-	-	
	3	TRANS. DIFF PROTN	1200-600/1	-	T. P.S.	1200/ 600	12/ 6	30 on 1000/1 Tap 60 on 500/1 Tap	

SECTION4 - SURGE ARRESTERS

1.0 GENERAL:

1.1 The Surge arresters shall conform to IEC: 60099-4 except to the extent modified in the specification and shall also be in accordance with requirements under Chapter 2 -GTR.

1.2 Arresters shall be of hermetically sealed units, self supporting construction, suitable for mounting on tubular support structures to be supplied by the Contractor.

1.3 The Surge Arrestors shall be designed for use in the geographic and meteorological conditions as given in the Chapter 2 -GTR.

2.0 DUTY REQUIREMENTS:

a. The surge arresters shall be of heavy duty station class and gapless type without any series or shunt gaps.

b. The surge arresters shall be capable of discharging over-voltages occurring during switching of unloaded transformers, reactors and long lines.

c. 420 kV class Surge arresters shall be capable of discharging of severe re-energisation switching surges on a 400 kV, 450 km long line with Surge impedance of 300 ohms and capacitance of 11.986nF/km and over voltage factor of 2.3 p.u.

d. 420 kV class arrester shall be capable of discharging energy equivalent to class 4 of IEC for a 420 kV system on two successive operation followed immediately by 50 Hz energisation with a sequential voltage profile as specified below:

650 kVp for 3 peaks
575 kVp for 0.1 Sec
550 kVp for 1 seconds
475 kVp for 10 seconds

e. 245/145/72.5/36 kV class arrester shall be capable for discharging energy equivalent to class 3 of IEC for 245/145/72.5/36 kV system on two successive operations.

f. The surge arresters shall be suitable for withstanding forces as defined in Chapter 2-GTR.

e. The reference current of the arresters shall be high enough to eliminate the influence of grading and stray capacitance on the measured reference voltage.

f. The surge arresters are being provided to protect the following equipment whose insulation levels are indicated in the table given below:-

Equipment to be protected	Lightning impulse(kVp) for 420 kV system	Switching Surge for 420 kV system	Lightning impulse(kVp) for 245 kV system	Lightning Surge for 145 kV system
Power transformer	+ 1300	+ 1050	± 950	± 550
Instrument Transformer	+ 1550	+ 1425	± 1050	± 650
Reactor	+ 1550	+ 1300	--	--
CB/Isolator Phase to ground	+ 1550	+ 1425	± 1050	± 650
CB/Isolator Across open contacts	+ 1140(-/+ 653)	+ 1425(-/+ 240)	± 1050(for CB) ± 1200(for Isolator	± 750

g. The duty cycle of CB installed in 420/245/145 kV System of the Purchaser shall be O-0.3 sec-CO-3 min-CO. The Surge Arrester shall be suitable for such circuit breaker duties in the system.

3.0 CONSTRUCTIONAL FEATURES:

The features and constructional details of surge arresters shall be in accordance with requirement stipulated hereunder:

a) The non-linear blocks shall be of sintered metal oxide material. These shall be provided in such a way as to obtain robust construction, with excellent mechanical and electrical properties even after repeated operations.

b) The surge arresters shall be fitted with pressure relief devices suitable for preventing shattering of porcelain housing and providing path for flow of rated fault currents in the event of arrester failure. Details shall be furnished in the bids alongwith quality checks.

c) The arresters shall not fail due to arrester porcelain contamination.

d) Seals shall be provided in such a way that these are always effectively maintained even when discharging rated lightning current.

e) Outer insulator shall be porcelain/polymer conforming to requirements stipulated in Chapter 2-GTR. Terminal connectors shall conform to requirements stipulated under Chapter 2-GTR.

The outer insulator housing shall be so coordinated that external flashover will not occur due to application of any impulse or switching surge voltage upto the maximum design value for arrester.

f) The end fittings shall be made of corrosion proof material and preferably be nonmagnetic.

g) The name plate shall conform to the requirements of IEC incorporating the year of manufacture.

h) The heat treatment cycle details alongwith necessary quality checks used for individual blocks alongwith insulation layer formed across each block are to be furnished. Metalizing coating thickness for reduced resistance between adjacent discs is to be furnished with additional information schedule of bid proposal sheets alongwith procedure for checking the same. Details of thermal stability test for uniform distribution of current on individual disc is to be furnished.

i) The manufacturer will submit Data for rejection rate of ZnO blocks during manufacturing/operation for the past three years.

j) **The sealing arrangement of the Surge Arrester stacks shall be done incorporating grooved flanges with the O-rings/elliptical cross-section gaskets of Neoprene or Butyl rubber.**

k) The Surge arrester with porcelain housing shall have a cantilever strength of not less than 500 kg, 350 kg and 350 kg for 336/216/120kV surge arresters respectively or as per the value obtained vide Chapter 2-GTR, whichever is higher. For Surge arrester with polymer housing, the cantilever strength shall not be less than 150kg.

4.0 FITTINGS AND ACCESSORIES:

a) 336/216/120/30 kV Arresters shall be complete with insulating base and Surge monitor having provision for bolting to flat surface of structure.

b) Self contained discharge counters, suitably enclosed for outdoor use and requiring no auxiliary or battery supply for operation shall be provided for each single pole unit alongwith necessary connection. Suitable leakage current meters should also be provided. The reading of milliammeter and counters shall be visible through an inspection glass panel. The terminals shall be robust and of adequate size and shall be so located that incoming and outgoing connections are made with minimum possible bends.

c) Surge monitor consisting of discharge counters and milliammeters should be suitable to be mounted on support structure of the arrester and should be tested for IP66 degree of protection. The standard supporting structure for surge arrester should be provided with a mounting pad, for fixing the surge monitor. The surge monitor should be suitable for mounting on this standard mounting pad. Also all nuts, bolts, washers etc. required for fixing the surge monitor shall have to be supplied by the Contractor.

The arrangement for Surge Monitor enclosure fixing to the structure shall be at its rear/bottom. Connection between the Surge Arrester base and Surge Monitor shall be through a 2.0 m(minimum) long insulated copper rod/strip of at least 75 sq.mm cross sectional area. The cable shall be terminated at rear/bottom side of the Surge Monitor. The gaskets of the surge monitors shall be of Neoprene, Butyl or equivalent material.

d) Grading/corona rings shall be provided on each complete arrester unit as required. Suitable terminal connectors shall be supplied by the Contractor.

5.0 TESTS:

5.1 **In accordance with the requirements stipulated under Chapter 2-GTR, the surge arresters should have been type tested as per IEC and shall be subjected to routine and acceptance tests in accordance with IEC document For contamination test, procedures outlined in 60099-3 shall be followed.**

The test reports of the type tests and the following additional type tests(additional type tests are required for Surge Arresters above 72.5 kV class only) shall also be submitted for the Purchaser's review.

i) Radio interference voltage test as per IEC 60099-4.

ii) Seismic withstand test.

iii) Contamination test.

iv) Test to verify the Power frequency versus time characteristics. Temporary over voltage profile for arresters are to be mutually agreed.

Each metal oxide block of surge arresters shall be tested for the guaranteed specific energy capability in addition to the routine/acceptance test as per IEC: 60099-4.

5.2 (a) **Acceptance Tests:**

1. Measurement of power frequency reference voltage of the arrester units.

2. Lightning Impulse Residual voltage on arrester units. (IEC clause 6.3.2).

3. Internal Ionisation or partial Discharge test.

(b) **Special Acceptance Test:**

1. Thermal stability test on three sections. (IEC Clause 7.2.2).

2. Aging & Energy Capability test on blocks (procedure to be mutually agreed).

3. Wattloss test.

(c) **Routine Tests:**

1. Sealing test: Water dip test at 1.5m depth from top of Surge Arrestor for 30 minutes shall be performed during assembly of Surge Arrester stacks (followed by other routine tests, i.e. P.D. Measurement, Reference Voltage, Residual Voltage & IR measurement).

2. Measurement of reference voltage.

3. Residual voltage test of arrester unit.

4. Internal Ionisation test or partial discharge test.

5. Verticality check on completely assembled Surge arresters as a sample test on each lot.

(d) **Test on Surge Monitors:**

The Surge monitors shall also be connected in series with the test specimens during residual voltage and current impulse withstand tests to verify efficacy of the same. Additional routine/ functional tests with one 100A and 10kA current impulse(8/20 micro sec.) shall also be performed on the Surge monitor.

Surge monitors shall be routinely tested for water dip test at 1.5m for 30 minutes. No water vapors shall be visible on the monitor glass.

(e) **Test on insulators**

All routine tests shall be conducted on the hollow column insulators as per IEC 62155. Polymer housing shall be tested in accordance to IEC-61462.

6.0 SPARE PARTS AND MAINTENANCE EQUIPMENT:

Bidder shall include in his proposal spare parts and maintenance equipment, as mentioned in Chapter 1-PSR.

7.0 TECHNICAL PARAMETERS:

A. 420 kV CLASS SURGE ARRESTER

A7.0(a)	Rated arrester voltage	336 kV
A7.0(b)	Nominal discharge current	20 kA of 8/20 microsecond wave
A7.0(c)	Minimum discharge capability	12kJ/kV (referred to rated arrester voltage corresponding to minimum discharge characteristics.
A7.0(d)	Continuous operating voltage at 50 deg.C	267 kV rms
A7.0(e)	Max. switching surge residual voltage (2kA)	670 kVp
A7.0(f)	Max. residual voltage at	
	i) 10 kA nominal discharge current	800 kVp
	ii) 20 kA nominal discharge current	850 kVp
	iv) Steep fronted wave residual voltage at 20 kA	925 kVp
A7.0(g)	Long duration discharge class	3

A7.0(h)	High current short duration test value (4/10 micro second wave)	100 kAp
A7.0(i)	Current for pressure relief test	40 kA rms / 50 kA rms (as applicable)
A7.0(k)	Low current long duration test value (2400 micro sec)	As per IEC.
A7.0(l)	Pressure relief class	40 kA / 50 kA (as applicable)

B. 245 kV CLASS SURGE ARRESTER

B7.0(a)	Rated arrester voltage	216 kV
B7.0(b)	Nominal discharge current	10 kA of 8/20 microsecond wave
B7.0(c)	Minimum discharge capability	5kJ/kV (referred to rated arrester voltage corresponding to minimum discharge characteristics.
B7.0(d)	Continuous operating voltage at 50 deg.C	168 kV rms
B7.0(e)	Max. switching surge residual voltage (1kA)	500 kVp
B7.0(f)	Max. residual voltage at	
	i) 5 kA	560 kVp
	ii) 10 kA nominal discharge current	600 kVp
B7.0(g)	Max. steep current impulse residual voltage at 10 kA.	650 kVp
B7.0(h)	Long duration discharge class	3
B7.0(i)	High current short duration test value (4/10 micro second wave)	100 kAp

B7.0(j)	Current for pressure relief test	40 kA rms / 50 kA rms (as applicable)
B7.0(k)	Low current long duration test value (2400 micro sec)	As per IEC.
B7.0(l)	Pressure relief class	40 kA / 50 kA (as applicable)

C **33kV Surge Arresters**

C7.0(a)	Rated arrester voltage	30 kV
C7.0(b)	Nominal discharge capability	10 kA of 8/20 microsecond wave
C7.0(c)	Minimum discharge capability	5kJ/kV (referred to rated arrester voltage corresponding to minimum discharge characteristics).
C7.0(d)	Continuous operating voltage at 50 deg.C	24 kV rms
c7.0(e)	Max. switching surge residual voltage (0.5kA)	63 kVp
C7.0(f)	Max. residual voltage	
	(i) 5 kA	80 kVp
	(ii) 10 kA nominal discharge current	85 kVp
C7.0(g)	Long duration discharge class	2
C7.0(h)	High current short duration test value (4/10 micro second wave)	100 kAp
C7.0(i)	Current for Pressure Relief test	40kA rms
C7.0(j)	Low current long duration test value (2000 micro sec)	As per IEC.
C7.0(k)	Pressure relief class as per IEC-60099-1	A

8.0 PRE-COMMISSIONING TESTS

8.1 An indicative list of tests is given below.

(a) operation check of LA counter.

(b) Insulation resistance measurement

(c) Capacitance and Tan delta measurement of individual stacks.

(d) Third harmonic resistive current measurement (to be conducted after energisation.)

Contractor shall perform any additional test based on specialties of the items as per the field Q.P./Instructions of the equipment Supplier or Purchaser without any extra cost to the Purchaser. The Contractor shall arrange all instruments required for conducting these tests alongwith calibration certificates and shall furnish the list of instruments to the Purchaser for approval.

CHAPTER 5: TECHNICAL SPECIFICATION OF TRANSFORMER

1. General

1.1. This specification covers design, engineering, manufacture, testing, delivery at site including all materials, accessories, spares, unloading, handling, proper storage at site, erection, testing and commissioning of the equipment specified.

1.2. The transformers shall in general have constant ohmic impedance between HV and IV on all taps. However, in case of parallel operation with the existing transformer,

i) The percentage impedance, vector group, OLTC connection & range etc. of the transformer is to be matched with that of the existing transformer.

ii) Necessary provision is to be kept in the transformer control scheme for parallel operation with the existing OLTC control scheme having provision of Master/Follower/Independent /off operation etc.

1.3. External or internal reactors shall not be used to achieve the specified HV/LV and IV/LV impedances. Further, matching of physical orientation, mounting rail gauge etc. shall be done to facilitate inter-changeability.

2. Transportation

2.1. The Contractor shall be responsible to select and verify the route, mode of transportation and make all necessary arrangement with the appropriate authorities for the transportation of the equipment. The dimension of the equipment shall be such that when packed for transportation, it will comply with the requirements of loading and clearance restrictions for the selected route. It shall be the responsibility of the contractor to coordinate the arrangement for transportation of the transformer for all the stages from the manufacturer's work to site.

2.2. The contractor shall carry out the route survey along with the transporter and finalize the detail methodology for transportation of transformer and based on route survey; any modification/ extension/ improvement to existing road, bridges, culverts etc. If required, shall be in the scope of the bidder.

2.3. The main tank of the transformer shall be inland transported on trailers equipped with GPS system for tracking the location of transformer at all times during transportation from manufacturer works to designated site. The contractor shall intimate to Employer about the details of transporter engaged for transportation of the Transformer for tracking the Transformer during transit. Requirement of **Hydraulic trailer** is envisaged for 400kV class transformers.

2.4. All metal blanking plates and covers which are specifically required to transport and storage of the transformer shall be considered part of the transformer and handed over to the Employer after completion of the erection. Bill of quantity of these items shall be included in the relevant drawing/document.

2.5. The Contractor shall despatch the transformer filled with dry air at positive Pressure. The necessary arrangement shall be ensured by the contractor to take care of pressure drop of dry air during transit and storage till completion of oil filling during erection. The total duration of storage at site with dry gas shall preferably be limited to three (3) months after which the Transformer shall be processed and filled with oil. The dry air cylinder(s) provided to maintain positive pressure can be taken back by the contractor after oil filling. A gas pressure testing valve with necessary pressure gauge and adaptor valve shall be provided.

In case, turrets are having insulation assembly and is transported separately then the same shall also be filled with dry air.

2.6. Transformer shall also be fitted with sufficient number of Electronic impact recorders (on returnable basis) during transportation to measure the magnitude and duration of the impact in all three directions. The acceptance criteria and limits of impact, which can be withstood by the equipment during transportation and handling in all three directions, shall not exceed“3g” for 50mSec (20Hz) or as per contractor standard, whichever is lower.

3. Performance

3.1. The transformers shall be used for bi-directional flow of rated power. The major technical parameters of single phase and three phase transformer units are defined at **Annexure - A**

3.2. Transformers shall be capable of operating under natural cooled condition up to the specified load. The forced cooling equipment shall come into operation by pre-set contacts of winding temperature indicator and the transformer shall operate as a forced cooling unit initially as ONAF up to specified load and then as OFAF. Cooling shall be so designed that during total failure of power supply to cooling fans and oil pumps, the transformer shall be able to operate at full load for at least ten (10) minutes without the calculated winding hot spot temperature exceeding 140 deg C. Transformers fitted with two coolers, each capable of dissipating 50 per cent of the loss at continuous maximum rating, shall be capable of operating for 20 minutes in the event of failure of the oil circulating pump or blowers associated with one cooler without the calculated winding hot spot temperature exceeding 140deg C at continuous max rating. The contractor shall submit supporting calculations for the above and the same shall be reviewed during design review.

3.3. The transformer shall be free from any electrostatic charging tendency (ECT) under all operating conditions when all oil circulation systems are in operation. In general, oil flow speed shall not exceed 1.0 m/sec within winding in the oil flow system of the transformers. The manufacturer shall ensure that there is no electrostatic charging tendency in the design.

3.4. The transformers shall be capable of being continuously operated at the rated MVA without danger, at any tapping with voltage variation of 10% corresponding to the voltage of that tapping.

3.5. The transformers shall be capable of being over loaded in accordance with IEC-60076- 7. There shall be no limitation imposed by bushings, tap changers etc. or any other associated equipment.

3.5.1. Tank hotspot shall not exceed 130 Deg. Celsius. Maximum ambient temperature shall be considered as 50 Deg. C.

3.6. The transformer and all its accessories including bushing/ built in CTs etc. shall be designed to withstand without damage, the thermal and mechanical effects of any external short circuit to earth and of short circuits at the terminals of any winding for a period of 2 secs. The short circuit level of the HV & IV System to which the transformers will be connected is as follows:

400kV system	- 50kA for 1 sec (sym, rms, 3 phase fault)
220kV system	- 40 kA for 1 sec (sym, rms, 3 phase fault)
132kV system	- 31.5 kA for 1 sec (sym, rms, 3 phase fault)
66kV system	- 31.5 kA for 1 sec (sym, rms, 3 phase fault)
33kV system	- 25 kA for 1 sec (sym, rms, 3 phase fault)

However, for transformer design purpose, the through fault current shall be considered limited by the transformer self-impedance only (i.e. $Z_S = 0$).

3.7. Transformer shall be capable of withstanding thermal and mechanical stresses caused by symmetrical or asymmetrical faults on any terminals. Mechanical strength of the transformer shall be such that it can withstand 3-phase and 1-phase through fault for transformer rated voltage applied to HV and / or IV terminals of transformer. The short circuit shall alternatively be considered to be applied to each of the HV, IV and tertiary (LV) transformer terminals as applicable. The tertiary terminals shall be considered not connected to system source. For short circuit on the tertiary terminals, the in-feed from both HV & IV system shall be limited by the transformer self-impedance only and the rated voltage of HV and IV terminals shall be considered. The maximum short circuit output current at the tertiary terminals shall be limited to a safe value to make the transformer short circuit proof.

The transformer shall be designed to withstand for short circuit duration of 2 seconds for Thermal stress and the same shall be verified during design review.

3.8. The maximum flux density in any part of the core and yoke at the rated MVA, voltage and frequency shall be such that under 10 % continuous over-voltage condition it does not exceed 1.9 Tesla at all tap positions.

3.9. Transformers shall withstand without damage, heating due to the combined voltage and frequency fluctuations which produce the following over fluxing conditions:

110 % for continuous
125 % for 1 minute
140 % for 5 seconds

3.10. The air core reactance of HV winding of transformer shall not be less than 20% for 400kV class Transformer.

3.11. **Tertiary Windings (if applicable as per Annexure - A)**

The tertiary windings shall be suitable for connection of reactors or capacitors which would be subjected to frequent switching and shall be suitable for connection to LT Transformer for auxiliary supply. All the windings shall be capable of withstanding the stresses which may be caused by such switching.

The Tertiary winding shall be designed to withstand mechanical and thermal stresses due to dead short circuit on its terminals.

3.12. **Radio Interference and Noise Level**

The transformers shall be designed with particular attention to the suppression of harmonic voltage, especially the third and fifth so as to minimize interference with communication circuit.

The noise level of transformer, when energized at normal voltage and frequency with fans and pumps running shall not exceed the values specified at Annexure - A, when measured under standard conditions.

3.13. **Dynamic Short Circuit Test requirement**

3.13.1. **For 400 kV Class Auto transformer**

For 315 MVA, 400/220/33kV, 3-Phase Auto transformer

Manufacturer should have successfully carried out Dynamic Short Circuit test as per IEC 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) on 315MVA, 400/220/33kV Autotransformer and shall enclose the relevant Test Report/certificate along with bid.

If the manufacturer had not successfully carried out Dynamic Short Circuit test on 315MVA, 400/220/33kV Auto transformer as per IEC 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) as on the originally scheduled date of bid opening, bidder have to carry out the out Dynamic Short Circuit test on 315MVA, 400/220/33kV Auto transformer from offered Manufacturer without no extra cost to the Client/Employer 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).

The validity of Dynamic Short Circuit test reports of transformer shall be within last 10 (ten) years prior to the originally scheduled date of bid opening. In case the test reports are of the test conducted earlier than 10 (ten) years prior to the originally Scheduled date of bid opening, the contractor shall repeat these test(s) at no extra cost to the Employer. Type test report of transformer manufacturing from the same manufacturing plant shall only be acceptable.

Further, design review of offered 400 kV Class Auto transformer shall be carried out based on the design of short circuit tested 315MVA Autotransformer.

<u>For 167 MVA, 400/√/ 220/√/33kV, 1-Phase Auto transformer</u>

Manufacturer should have successfully carried out Dynamic Short Circuit test as per IEC 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) on 167 MVA, 400/√3/220/√3/33kV, 1- Phase Autotransformer and shall enclose the relevant Test Report/certificate along with bid.

If the manufacturer had not successfully carried out Dynamic Short Circuit test on 167 MVA, 400/√3/220/√3/33kV Auto transformer as per IEC 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) as on the originally scheduled date of bid opening, bidder have to carry out the out Dynamic Short Circuit test on 167 MVA, 400/√3/220/√3/33kV, 1- Phase Auto transformer from offered Manufacturer without no extra cost to the Client/Employer 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).

The validity of Dynamic Short Circuit test reports of transformer shall be within last 10 (ten) years prior to the originally scheduled date of bid opening. In case the test reports are of the test conducted earlier than 10 (ten) years prior to the originally Scheduled date of bid opening, the contractor shall repeat these test(s) at no extra cost to the Employer. Type test report of transformer manufacturing from the same manufacturing plant shall only be acceptable.

Further, design review of offered 400 kV Class Auto transformer shall be carried out

based on the design of short circuit tested Autotransformer.

4. Measurable Defects

The following shall constitute as Measureable Defects for the purpose of Defect Liabilities as per relevant clauses of GCC / SCC of the bidding document:

a) Repair, inside the Transformer and OLTC (including oil migration) either at site or at factory is carried out after commissioning.

b) The concentration of any fault gas is more than values of condition-1 indicated in clause no 6.5 of IEEE-C57.104-2008, which are as detailed below.

H2	CH4	C2H2	C2H4	C2H6	CO	CO2	TDCG
100	120	1	50	65	350	2500	720

c) The winding tan delta goes beyond 0.005 or increase more than 0.001 within a year w.r.t. pre-commissioning values. No temperature correction factor shall be applicable.

d) The moisture content goes above 12 ppm at any temperature during operation including full load.

5. Design review

5.1. The transformer shall be designed, manufactured and tested in accordance with the best international engineering practices under strict quality control to meet the requirement stipulated in the technical specification. The manufacturer will be required to demonstrate the adequate safety margin w.r.t thermal, mechanical, dielectric and electrical stress etc. shall be maintained during design, selection of raw material, manufacturing process etc. in order to achieve long life of transformer with least maintenance and to take into account the uncertainties of his design and manufacturing processes. The scope of such design review shall include but not limited to the requirement as mentioned at Annexure – D.

5.2. Raw material and sub-vendors used by transformer manufacturer shall be declared before commencement of manufacturing. **The validity of Type tests (except dynamic short circuit test) of Transformer shall be as per Chapter 2- General Technical Requirement (GTR),** provided that offered transformer design is identical to the type tested transformer and same active materials (CRGO, Conductor and Insulation) of same grade & from the same sub-vendors are used. In case of any change of either active materials or sub-vendors, the type tests shall be carried out by the contractor at no extra cost to Employer. Transformer type test report from the same manufacturing plant shall only be acceptable. With regard to Validity of Dynamic short circuit test, refer clause

3.13 above.

5.3. Design reviews shall be conducted by Employer or an appointed consultant during the procurement process for transformers; however, the entire responsibility of design shall be with the manufacturer. Employer may also visit the manufacturer's works to inspect design, manufacturing and test facilities at any time.

5.4. The design review will commence after placement of award with the successful bidder and shall be finalized before commencement of manufacturing activity. These design reviews shall be carried out in detail to the specific design with reference of the transformer under the scope of this specification. It shall be conducted generally following the "Guidelines for conducting design reviews for transformers - 100 MVA and 123 kV and above" prepared by CIGRE SC 12 Working Group 12.22.

5.5. The manufacturer shall provide all necessary information and calculations to demonstrate that the transformer meets the requirements for short circuit strength and durability. The latest recommendations of IEC and CIGRE SC 12 shall be applied for short circuit withstand evaluation.

6. Construction Details

The construction details and features of transformer shall be in accordance with the requirement stated hereunder. The components and fitting associated with transformers are subject to Employer's approval.

6.1. Tank

6.1.1. Tank shall be of welded/bolted construction and fabricated from tested quality low carbon steel of adequate thickness. Unless otherwise approved, metal plate, bar and sections for fabrication shall comply with BS-4360 / IS 2062. Material Samples, technical literature, drawings, test reports and list of the names of the principal users with experience gained shall be supplied on request.

6.1.2. All seams and joints which are not required to be opened at site, shall be factory welded, and wherever possible they shall be double welded. Welding shall conform to BS-5135/IS9595. After fabrication of tank and before painting, dye penetration test shall be carried out on welded parts of jacking bosses, lifting lugs and all load bearing members. The requirement of post weld heat treatment of tank/stress relieving shall be based on recommendation of BS-5500 table 4.4.3.1/IS 10801.

6.1.3. Tank stiffeners shall be provided for general rigidity and these shall be designed to prevent retention of water.

6.1.4. The tank shall be of proven design either bell type with bolted /welded joint or conventional type with welded / bolted top cover. Bell type tank shall be provided with joint at about 500 mm above the bottom of the tank. The welded joint shall be provided with flanges suitable for repeated welding. The joint shall be provided with a suitable gasket to prevent weld splatter inside the tank. Proper tank shielding shall be done to prevent excessive temperature rise at the joint.

6.1.5. Tank shall be provided with:

a. Lifting lugs: Four symmetrically placed lifting lugs shall be provided so that it will be possible to lift the complete transformer when filled with oil without structural damage to any part of the transformer. The factor of safety at any one point shall not be less than 2.

b. A minimum of four jacking pads in accessible position to enable the transformer complete with oil to be raised or lowered using hydraulic jacks.

c. Each jacking pad shall be designed to support with an adequate factor of safety at least half of the total mass of the transformer filled with oil allowing in addition to maximum possible misalignment of the jacking force to the center of the working surface.

d. Suitable haulage holes shall be provided.

e. Provision of 04 nos. of Gate valves for UHF sensors for PD Measurements at various locations. Location of valves shall be finalized during detailed engineering.

f. Suitable provisions of pockets for OTI, WTI & RTDs including two spare pockets.

6.1.6. The tank shall be designed in such a way that it can be mounted either on the plinth directly or on rollers, as per manufacturer's standard practice.

6.1.7. The base of each tank shall be so designed that it shall be possible to move the complete transformer unit by skidding in any direction without damage when using plates or rails.

6.2. **Tank Cover**

6.2.1. The tank cover shall be designed to prevent retention of water and shall not distort when lifted. The internal surface of the top cover shall be shaped to ensure efficient collection and direction of free gas to the buchholz relay.

6.2.2. At least two adequately sized inspection openings one at each end of the tank, shall be provided for easy access to bushings and earth connections. The inspection covers shall not weigh more than 25 kg. Handles shall be provided on the inspection cover to facilitate lifting.

6.2.3. The tank cover shall be provided with pockets for oil and winding temperature indicators. The location of pockets (for OTI, WTI & RTDs including two spare pockets) shall be in the position where oil reaches maximum temperature. Further, it shall be possible to remove bulbs of OTI/WTI/RTD without lowering the oil in the tank. The thermometer shall be fitted with a captive screw to prevent the ingress of water.

6.2.4. Bushing turrets, covers of inspection openings, thermometer pockets etc. shall be designed to prevent ingress of water into or leakage of oil from the tank.

6.2.5. To allow for the effect of possible induced and capacitive surge current flow, the tank cover and bushing turret shall be fixed to the transformer in such a way that good electrical contact is maintained around the perimeter of the tank and turrets.

6.2.6. The transformer shall be provided with a suitable diameter pipe flange, butterfly valve, bolted blanking plate and gasket shall be fitted at the highest point of the transformer for maintaining vacuum in the tank.

6.2.7. **Gas venting** - The transformer cover and generally the internal spaces of the transformer and all pipe connections shall be designed so as to provide efficient venting of any gas in any part of the transformer to the Buchholz relay. The space created under inspection /manhole covers shall be filled with suitable material to avoid inadvertent gas pockets. The Covers shall be vented at least at both longitudinal ends. The design for gas venting shall take into accounts the slopes of the plinth (if any) on which the transformer is being mounted.

6.3. Gasket for tank & cover

All gasketed joints shall be designed, manufactured and assembled to ensure long-term leak and maintenance free operation. All gasketed joints shall preferably of O-ring and groove type. The Gaskets / O-Ring in contact with oil shall be Nitrile rubber or any other better approved quality.

All bolted connections shall be fitted with weather proof, hot oil resistant, resilient gasket in between for complete oil tightness. If gasket is compressible, metallic stops/other suitable means shall be provided to prevent over-compression.

The properties of all the above gaskets / O-Rings shall comply with the requirements of IS-11149. Gaskets and O-rings shall be replaced every time whenever the joints are opened.

6.4. Roller Assembly and Anti Earthquake Clamping Device

The roller mounted transformers are to be provided with flanged bi-directional wheels and axles. This set of wheels and axles shall be suitable for fixing to the under carriage of transformer to facilitate its movement on rail track. Suitable locking arrangement along with foundation bolts shall be provided for the wheels to prevent accidental movement of transformer. The rail track gauge shall be 1676 mm.

To prevent transformer movement during earthquake, suitable clamping devices shall be provided for fixing the transformer to the foundation.

6.5. **Conservator**

6.5.1. Main tank conservator shall have air cell type constant oil pressure system to prevent oxidation and contamination of oil due to contact with moisture. Conservator shall be fitted with magnetic oil level gauge with potential free high and low oil level alarm contacts and prismatic oil level gauge.

6.5.2. Conservator tank shall have adequate capacity with highest and lowest visible-levels to meet the requirements of expansion of total cold oil volume in the transformer and cooling equipment from minimum ambient temperature to top oil temperature of 110 deg C. The capacity of the conservator tank shall be such that the transformer shall be able to carry the specified overload without overflowing of oil.

6.5.3. The conservator shall be fitted with lifting lugs in such a position so that it can be removed for cleaning purposes. Suitable provision shall be kept to replace air cell and cleaning of the conservator as applicable.

6.5.4. Conservator shall be positioned so as not to obstruct any electrical connection to transformer.

6.5.5. The connection of air cell to the top of the conservator is by air proof seal preventing entrance of air into the conservator. The main conservator tank shall be stenciled on its underside with the words **"Caution: Air cell fitted".** Lettering of at least 150 mm size shall be used in such a way to ensure clear legibility from ground level when the transformer is fully installed. To prevent oil filling into the air cell, the oil filling aperture shall be clearly marked. The transformer rating and diagram plate shall bear a warning statement that the **"Main conservator is fitted with an air cell".**

6.5.6. Contact of the oil with atmosphere is prohibited by using a flexible air cell of nitrile rubber reinforced with nylon cloth. The temperature of oil in the conservator is likely to raise up to 110 degree C during operation. As such air cell used shall be suitable for operating continuously at this temperature.

6.5.7. The transformer manual shall give full and clear instructions on the operation, maintenance, testing and replacement of the air cell. It shall also indicate shelf life, life expectancy in operation, and the recommended replacement intervals.

6.5.8. The conservator tank and piping shall be designed for complete vacuum / filling of the main tank and conservator tank. Provision must be made for equalizing the pressure in the conservator tank and the air cell during vacuum / filling operations to prevent rupturing of the air cell.

6.5.9. The contractor shall furnish the leakage rates of the rubber bag/ air cell for oxygen and moisture. It is preferred that the leakage rate for oxygen from the air cell into the oil will be low enough so that the oil will not generally become saturated with oxygen. Air cells with well proven long life characteristics shall be preferred.

6.6. Piping works for conservator

6.6.1. Pipe work connections shall be of adequate size preferably short and direct. Only radiused elbows shall be used.

6.6.2. The feed pipe to the transformer tank shall enter the transformer cover plate at its highest point and shall be straight for a distance not less than five times its internal diameter on the transformer side of the Buchholz relay, and straight for not less than three times that diameter on the conservator side of the relay. Gas-venting pipes shall be connected to the final rising pipe between the transformer and Buchholz relay as near as possible in an axial direction and preferably not less than five times pipe diameters from the Buchholz relay.

6.6.3. This pipe shall rise towards the oil conservator, through the Buchholz relay, at an angle of not less than 5 degrees.

6.6.4. A double flange valve of preferably 50 mm and 25 mm size shall be provided to fully drain the oil from the main tank conservator and OLTC conservator tank respectively.

6.6.5. The feed pipe diameter for the main conservator shall be not less than 80mm.

6.6.6. Pipe work shall neither obstruct the removal of tap changers for maintenance or the opening of inspection or manhole covers.

6.7. Maintenance-free Dehydrating Breather

Conservator of Main Tank and OLTC shall be fitted with a maintenance-free dehydrating breather. Connection shall be made to a point in the oil conservator not less than 50 mm above the maximum working oil level by means of a pipe with a minimum diameter of 25 mm. Breathers and connecting pipes shall be securely clamped and supported to the transformer, or other structure supplied by the contractor, in such a manner so as to eliminate undesirable vibration and noise. The design shall be such that:

a) Incoming air is directed toward the desiccant (silica gel) and dried.
b) The desiccant is regenerated/dehumidified by an installed heating element that shall be sensor-controlled and self-regulating.
c) Silicagel is isolated from atmosphere by an oil seal.
c) Moisture absorption indicated by a change in color of the crystals.
d) Breather is mounted approximately 1200 mm above rail top level.
e) To minimize the ingress of moisture three breathers (of identical size) shall be connected in series for main tank conservator. Contractor shall provide flexible connection pipes to be used during replacement of any breather.
f) To minimize the ingress of moisture, two in series of identical size shall be connected to OLTC Conservator. Contractor shall provide flexible connection pipes to be used during replacement of any breather.

6.8. Pressure Relief Device

Adequate number of pressure relief devices (at least 2 numbers) shall be provided at suitable locations preferably close to bushing turret/ cover. These shall have opening diameter of at least 100 mm for rapid release of any pressure that may be generated in the tank and which may result in damage to equipment. The device shall maintain its oil tightness under static oil pressure equal to the static operating head of oil plus 20 kPa. The device shall operate and attain its full opening in not more than 2.5 ms when subject to an internal pressure impulse equal to static operating head of oil plus 50 kPa. It shall be capable of withstanding full internal vacuum at mean sea level. It shall be mounted directly on the tank. One set of potential free contacts (**with plug & socket type arrangement suitable for 2.5sq.mm control cable)** per device shall be provided for tripping. Following routine tests shall be conducted on PRD:

a) Air pressure test
b) Liquid pressure test
c) Leakage test
d) Contact operation test
e) Dielectric test on contact terminals

6.9. Sudden Pressure Relay

Adequate number of Sudden Pressure relay with alarm/trip contacts **(Plug & socket type arrangement suitable for 2.5sq.mm control cable)** shall be provided on tank of Transformer. Operating features, size and quantity shall be reviewed during design review. Pressurized water ingress test for Terminal Box (routine tests) shall be conducted on Sudden Pressure Relay.

6.10. **Buchholz Relay**

Two numbers double float, reed type Buchholz relay shall be provided in series of the connecting pipe between the oil conservator and the Transformer tank with minimum distance of five times pipe diameters between them. Any gas evolved in the Transformer shall be collected in this relay. The relay shall be provided with a test cock suitable for a flexible pipe connection for checking its operation and taking gas sample. A copper tube shall be connected from the gas collector to a valve located about 1200 mm above ground level to facilitate sampling while the Transformer in service. Each device shall be provided with two potential free contacts **(Plug & socket type arrangement suitable for 2.5sq.mm control cable),** one for alarm / trip on gas accumulation and the other for tripping on sudden rise of pressure.

The Buchholz relay shall not operate during starting/ stopping of the transformer oil circulation under any oil temperature conditions. The pipe or relay aperture baffles shall not be used to decrease the sensitivity of the relay. The relay shall not mal-operate for through fault conditions or be influenced by the magnetic fields around the transformer during the external fault conditions. Pressurized water ingress test for Terminal Box (routine tests) shall be conducted on Buchholz relay.

6.11. **Oil Temperature Indicator (OTI)**

All transformers shall be provided with a dial type thermometer of around 150 mm diameter for top oil temperature indication. It shall have adjustable, potential free alarm and trip contacts **(Plug & socket type arrangement suitable for 2.5sq.mm control cable)** besides that required for control of cooling equipment if any. A temperature sensing element suitably located in a pocket on top oil shall be provided. This shall be connected to the OTI by means of capillary tubing. Temperature indicator dials shall have linear gradations to clearly read at least every 2 deg C. Accuracy of OTI shall be 3.0 deg C or better for a temperature of 100 deg C.

The setting of alarm and tripping contacts shall be adjustable at site. For alarm & trip settings refer EMPLOYER Pre-Commissioning Procedures and formats for switchyard equipment, same shall be finalized during detail engineering.

In addition to the above, the following accessories shall be provided for remote indication of oil temperature:

a) Temperature transducer with Pt100 sensor

RTD shall be provided with Pt100 temperature sensor having nominal resistance of 100 ohms at zero degree centigrade. The Pt100 temperature sensor shall have three wire ungrounded system. The calibration shall be as per IEC 60751-2 or equivalent. The Pt100 sensor may be placed in the pocket containing temperature sensing element. RTD shall provide dual output 4-20mA for remote OTI and SCADA system individually. The transducer shall be installed in the Individual Marshalling Box. Any special cable required for shielding purpose, for connection between Pt100 temperature sensor and transducer, shall be in the scope of Contractor.

b) Remote oil temperature indicator

It shall be suitable for flush mounting on Employer's control panel/ digital RTCC panel and shall operate on 4-20mA input available from the above transducer. Any special cable required for shielding purpose, for connection among Individual Marshalling Box, Common Marshalling Box/Cooler control cabinet and remote OTI control circuit, shall be in the scope of Contractor.

6.12. Winding Temperature Indicator (WTI)

All Transformers shall be provided with a device for measuring the hot spot temperature of each winding (HV, IV and LV) with dial type thermometer of 150 mm diameter for winding temperature indication and shall have adjustable potential free alarm and trip contacts **(Plug & socket type arrangement suitable for 2.5sq.mm control cable**) besides that required for control of cooling equipment if any. WTI shall have Temperature sensing element, Image coil and Auxiliary CTs, if required to match the image coil, shall be mounted in the cooler control cabinet. Temperature indicator dials shall have linear gradations to clearly read at least every 2 deg C. Accuracy of WTI shall be 3.0 deg C or better for a temperature of 100 deg C.

The setting of alarm and tripping contacts shall be adjustable at site. For alarm & trip settings refer EMPLOYER Pre-Commissioning Procedures and formats for switchyard equipment, same shall be finalized during detail engineering.

In addition to the above, the following accessories shall be provided for remote indication of oil temperature:

a) Temperature transducer with Pt100 sensor for each winding

RTD shall be provided with Pt100 temperature sensor having nominal resistance of 100 ohms at zero degree centigrade. The Pt100 temperature sensor shall have three wire ungrounded system. The calibration shall be as per IEC 60751-2 or equivalent. The Pt100 sensor may be placed in the pocket containing temperature sensing element. RTD shall include image coil, Auxiliary CTs, if required to match the image coil, for WTI system and shall provide dual output 4-20mA for remote WTI and SCADA system individually. The transducer, Auxiliary CT shall be installed in the Individual Marshalling Box. Any special cable required for shielding purpose, for connection between Pt100 temperature sensor and transducer, shall be in the scope of Contractor.

b) Remote winding temperature indicator (RWTI)

It shall be suitable for flush mounting on control panel/ digital RTCC panel and shall operate on 4-20mA input available from the above transducer. Any special cable required for shielding purpose, for connection among Individual Marshalling Box / Cooler control cabinet, Common Marshalling Box and remote WTI control circuit, shall be in the scope of Contractor.

Only one RWTI with suitable selector switches or separate individual RWI shall be provided for display of temperature of all the three windings (HV, IV and LV as applicable).

6.13. The temperature indicators (OTI & WTI) shall be so mounted that the dials are About 1200 mm from ground level. Glazed door of suitable size shall be provided for convenience of reading.

6.14. **Optical sensors & temperature measuring unit**

Each Transformer unit shall be fitted with at least 16 numbers optical temperature sensors. The optical sensors based temperature measuring system shall be of direct measurement non calibrating type. All the sensors shall be brought out to separate optical sensor box mounted on transformer tank to facilitate measurement of temperature during service life on each unit.

In order to facilitate measurement of temperature from the optical sensors, temperature measuring unit/system having at least 16 channels shall be mounted in above optical sensor box (stainless steel, IP 55 Protection) for each transformer unit**.** The measuring unit shall be capable to retain temperature data for at least 30 days with facility to download these data.

Temperature measuring unit/system housed in above box shall be suitable for satisfactory operation with ambient conditions and IEC 61850 compliant to interface with Employer's SCADA system.

Location of optical temperature sensors inside the transformer shall be decided during design review. Manufacturers are advised to provide few more optical temperature sensors (probes) to take care of any damage during handling.

6.15. **Earthing Terminals**

6.15.1. Two (2) earthing pads (each complete with two (2) nos. holes, with suitable bolts, plain and spring washers) suitable for connection to copper flat conductor cable or stranded copper wire of minimum size (cross sectional area) 160sq. mm (shall be finalized exact size during detail engineering) shall be provided each at position close to earth of the two (2) diagonally opposite bottom corners of the tank.

6.15.2. Two earthing terminals suitable for connection to copper flat conductor cable or stranded copper wire of minimum size (cross sectional area) 160sq. mm (shall be finalized exact size during detail engineering) shall also be provided on each cooler, individual/common marshalling box and any other equipment mounted separately. For the tank-mounted equipment like online drying/ Online DGA/ Optical Sensor Box etc. double earthing shall be provided through the tank for which provision shall be made through tank and connected through two flexible insulated copper link.

6.15.3. Equipotential flexible copper link of suitable size at least 4 Nos. for Tank mounted turret with tank and tank with cover and or Bell shall be provided. For other components like - pipes, conservator support etc. connected to tank shall also be provided with equipotential flexible copper link.

6.16. **Core**

6.16.1. The core shall be constructed from high grade, non-ageing, cold rolled, super grain oriented silicon steel laminations (HI-B or better grade).

6.16.2. The design of the magnetic circuit shall be such as to avoid static discharges, development of short circuit paths within itself or to the earthed clamping structure and production of flux component at right angles to the plane of laminations which may cause local heating.

6.16.3. The temperature of any part of the core or its support structure in contact with oil shall not exceed 120 deg C under normal operating condition and 130 deg C under 10% over voltage and maximum ambient air temperature conditions of 50 deg C. Adequate temperature margin shall be provided to maintain the long life expectancy for this material.

6.16.4. Core and winding shall be capable of withstanding the shock during transport, installation and service. Adequate provision shall be made to prevent movement of core and winding relative to tank during these conditions.

6.16.5. All steel sections used for supporting the core shall be thoroughly sand / shot blasted after cutting, drilling and welding.

6.16.6. Each core lamination shall be insulated with a material that will not deteriorate due to pressure and hot oil.

6.16.7. The supporting frame work of the core shall be so designed as to avoid presence of pockets which would prevent complete emptying of tank through drain valve or cause trapping of air during oil filling.

6.16.8. Adequate lifting lugs will be provided to enable the core and windings to be lifted.

6.16.9. The core shall be earthed to the core clamping structure at one point only, through a removable external link of minimum size of 80 sq. mm copper suitably located and protected to facilitate testing after installation of the transformer. The removable links shall have adequate section to carry ground fault current. Separate identification name plate/labels shall be provided for the 'Core' and 'Core clamp' on the outside of tank cover.

6.16.10. In case core laminations are divided into sections by insulating barriers or cooling ducts parallel to the plane of the lamination, tinned copper bridging strips shall be inserted to maintain electrical continuity between sections.

6.17. **Windings**

6.17.1. The Contractor shall ensure that windings of all transformers are made in dust proof and conditioned atmosphere.

6.17.2. The conductors shall be of electrolytic grade copper free from scales and burrs.

6.17.3. The insulation of transformer windings and connections shall be free from insulating compounds which are liable to soften, ooze out, shrink or collapse and shall be non- catalytic and chemically inactive in transformer oil during service.

6.17.4. Coil assembly and insulating spacers shall be so arranged as to ensure free circulation of oil and to reduce the hot spot of the winding.

6.17.5. The coils would be made up, shaped and braced to provide for expansion and contraction due to temperature changes.

6.17.6. The conductor shall be transposed at sufficient intervals in order to minimize eddy currents and to equalize the distribution of currents and temperature along the winding.

6.17.7. The windings shall be designed to withstand the dielectric tests specified. The type of winding used shall be of time tested. An analysis shall be made of the transient voltage distribution in the windings, and the clearances used to withstand the various voltages. Margins shall be used in recognition of manufacturing tolerances and considering the fact that the system will not always be in the new factory condition.

6.17.8. The barrier insulation including spacers shall be made from high- density pre- compressed pressboard (1.1 gm/cc minimum for load bearing and 1 to 1.3 gm/cc minimum for non-load bearing) to minimize dimensional changes.

6.17.9. The conductor insulation shall be made from high-density (at least 0.75 gm/cc) paper having high mechanical strength. The characteristics for the paper will be reviewed at the time of design review.

6.17.10. Wherever required, electrostatic shield, made from material that will withstand the mechanical forces, will be used to shield the high voltage windings from the magnetic circuit.

6.17.11. All winding insulation shall be processed to ensure that there will be no detrimental shrinkage after assembly. All windings shall be pre-sized before being clamped.

6.17.12. Windings shall be provided with clamping arrangements which will distribute the clamping forces evenly over the ends of the winding.

6.17.13. The bracing of the windings and connections shall be such that these parts shall safely withstand the cumulative effects of stresses which may occur during handling, transportation, installation and service including line-to–line and line-to–ground faults.

6.18. Current carrying connections

The mating faces of bolted connections shall be appropriately finished and prepared for achieving good long lasting, electrically stable and effective contacts. All lugs for crimping shall be of the correct size for the conductors. Connections shall be carefully designed to limit hot spots due to circulating eddy currents.

6.19. Winding terminations into bushings

6.19.1. Winding termination interfaces with bushings shall be designed to allow for repeatable and safe connection under site conditions to ensure the integrity of the transformer in service.

6.19.2. The winding end termination, insulation system and transport fixings shall be so designed that the integrity of the insulation system generally remains intact during repeated work in this area.

6.19.3. Allowances shall be made on the winding ends for accommodating tolerances on the axial dimensions of the set of bushings and also for the fact that bushings may have to be rotated to get oil level inspection gauges to face in a direction for ease of inspection from ground level.

6.19.4. In particular, rotation or straining of insulated connections shall be avoided during the fastening of conductor pads (or other methods) on the winding ends onto the termination surfaces of the bushing.

6.19.5. Suitable inspection and access facilities into the tank in the bushing oil-end area shall be provided to minimize the possibility of creating faults during the installation of bushings.

7. Paint system and procedures

The typical painting details for transformer main tank, pipes, conservator tank, radiator, control cabinet/ marshalling box / oil storage tank etc. shall be as given in **Annexure – E**. The proposed paint system shall generally be similar or better than this. The quality of paint should be such that its colour does not fade during drying process and shall be able to withstand temperature up to 120 deg C. The detailed painting procedure shall be finalized during award of the contract.

8. Inhibited Insulating Oil

The insulating oil shall be virgin high grade inhibited, conforming to IEC-60296 & all parameters specified at **Annexure – F**, while tested at oil supplier's premises. The contractor shall furnish test certificates from the supplier against the acceptance norms as mentioned at **Annexure – F**, prior to despatch of oil from refinery to site. Under no circumstances, poor quality oil shall be filled into the transformer and thereafter be brought up to the specified parameter by circulation within the transformer. The Unused inhibited Insulating Oil parameters including parameters of oil used at manufacturer's works, processed oil, oil after filtration and settling are attached at **Annexure – F**. The oil test results shall form part of equipment test report.

Sufficient quantity of oil necessary for maintaining required oil level in case of leakage in tank, radiators, conservator etc. till the completion of warranty period shall be supplied.

Inhibited oil used for first filling, testing and impregnation of active parts at manufacturer's works shall be of same type of oil (in line with IEC 60076-3) which shall be supplied at site and shall meet parameters as per specification.

8.1. **Particles in the oil**

The particle analysis shall be carried out in an oil sample taken after completion of the oil filtration at site. The procedure and interpretation shall be in accordance with the recommendation of CIGRE report WG-12.17 - "Effect of particles on transformer dielectric strength".

8.2. **Moisture content in the solid insulation**

Dummy insulation test block shall be inserted in the active part of Transformer at factory and same shall be used to detect the volume moisture content. Before application of vacuum and oil filling in the Transformer, it will be ensured that moisture content in the dummy insulation test block is less than 0.5%.Measurement shall be carried out as per IEC.

8.3. **Oil filling**

8.3.1. Procedures for site drying, oil purification, oil filling etc. shall be done as per EMPLOYER Quality Plan (QP).

8.3.2. The duration of the vacuum treatment shall be demonstrated as adequate by means of water / dew point measurement with a cold trap or other suitable method. The vacuum shall be measured on the top of the transformer tank and should be less than 1mbar.

8.3.3. Oil filling under vacuum at site shall be done with transformer oil at a temperature not exceeding 65°C. Vacuum shall not be broken until the Transformer is oil filled up to the Buchholz relay.

8.3.4. The minimum safe level of oil filling (if different from the Buchholz level) to which the Transformer shall be oil filled under vacuum, shall be indicated in the manual.

8.3.5. The Ultra High Vacuum type oil treatment plant of suitable capacity (**minimum 6000** litres per hour) suitable for treatment of oil in EHV class Transformer shall be used in order to achieve properties of treated oil. The plant shall be capable of treatment of new oil (as per IEC 60296 and reconditioning of used oil (as per IS: 1866/IEC: 60422 for oil in service) at rated capacity on single pass basis as follow:

i) Removal of moisture from 100 ppm to 3 ppm (max.)
ii) Removal of dissolved gas content from 10% by Vol. to 0.1% by vol.
iii) Improvement of dielectric strength break down voltage from 20 to 70 KV
iv) Vacuum level of degassing chamber not more than 0.15 torr/0.2 mbar

at rated flow and at final stage. Machine shall have minimum of two degassing chambers and these should have sufficient surface areas to achieve the final parameters.

v) Filter shall be capable of removing particle size more than 0.5 micron in the filtered oil.

vi) Processing temperature shall be automatically controlled and have an adjustable range from 40 C to 80 C.

The above oil treatment plant (Filtration unit) shall be arranged by the bidder at his own cost.

8.3.6. **Transportation of Oil**

The insulating oil for the transformer shall be delivered at site generally not before 90 days from the date of commissioning, with prior information to the Employer.

Insulating oil shall be delivered to the site in returnable oil drums / flexi bag / tanker. The oil drums / flexi bag / tanker shall be taken back without any extra cost to Employer within generally 45 days after utilisation of oil but in any case before contract closing. However, the spare oil shall be delivered in non-returnable drums.

9. Preparation of spare unit

9.1. **Unit in service:** In case, Employer intends to replace any of the 1-phase Transformer units by spare 1-phase unit through isolator switching arrangement i.e. without physically shifting of the Transformers, the spare Transformer shall be completely erected, oil filled and commissioned similar to the other Transformers.

It shall be noted that the transformer being of four (4) Nos. Single phase units, the GIB connections shall permit spare unit (i.e. the fourth unit) through isolator switching arrangement and interchanging of any of the transformers for loading without physical movement. The detailed arrangements/connections diagram alongwith Bill of Quantity shall be submitted by the Bidder alongwith the bid and deem to be included in the present scope of the work.

9.2. **Unit for long term storage:** In case, due to space limitation, Isolator based switching arrangement is not possible, the faulty unit shall be replaced with spare unit by physical shifting. The spare unit shall be completely erected at the identified location/foundation in the substation, oil filled and commissioned similar to the other Transformers with all accessories (except cooler/radiator bank) for long-term storage. The contractor shall carry out all pre-commissioning tests on the spare Transformer similar to the unit kept in service. After completion of pre-commissioning tests, bushings may be dismantled and re-packed or erected condition as advised by Employer. If the conservator is mounted on cooler bank, suitable arrangement shall be made for the conservator to be mounted on tank top during long-term storage of Transformer. Radiators shall be kept in original packing and shall be stored as per the direction of site Engineer in charge or in erected condition wherever storage space not available.

All other accessories/fittings etc. shall be suitably packed in reusable boxes in line with standard drawings/documents. Instructions for dismantling, installation and safe storage shall be provided with every packing box. Arrangement shall be made to minimize moisture ingress inside the boxes. All pipes and radiators shall be provided with blanking plates during storage to prevent entry of foreign material/ water.

In addition to the blanking plates & covers provided during transportation, one complete set of all metal blanking plates and covers, which are specifically required during transport and storage at site shall be considered as integral part of each Transformer and handed over to the site packed in a separate box. Bill of quantity and relevant drawings of these items shall also be provided to enable the Employer to re- fabricated, if required.

In case spare Transformer needs to be commissioned similar to the unit in service, as advised by Employer, the same shall be erected, tested and commissioned as per standard procedures. However, other accessories/fittings/packing materials etc. As required for long-term storage shall be considered include in the scope of bidder.

Any special maintenance procedure required during long-term storage shall be clearly brought out in the instruction manual.

10. Bushings

10.1. Bushings shall be robust and designed for adequate cantilever strength to meet the requirement of seismic condition, substation layout and movement along with the spare Transformer with bushing erected and provided with proper support from one foundation to another foundation within the substation area. The electrical and mechanical characteristics of bushings shall be in accordance with IEC: 60137/DIN 42530. All details of the bushing shall be submitted for approval and design review.

10.2. Bushing for voltage of 52 kV and above shall be RIP bushing with composite insulator. 36 kV bushing shall be solid porcelain or oil communicating type.

10.3. RIP type bushing shall be provided with tap for capacitance and tan delta test. Test taps relying on pressure contacts against the outer earth layer of the bushing is not acceptable.

10.4. Where current transformers are specified, the bushings shall be removable without disturbing the current transformers.

10.5. Bushings of identical rating shall be interchangeable to optimize the requirement of spares.

10.6. Porcelain used in bushing manufacture shall be homogenous, free from lamination, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.

10.7. Polymer / composite insulator shall be seamless sheath of a silicone rubber compound. The housing & weather sheds should have silicon content of minimum 30% by weight. It should protect the bushing against environmental influences, external pollution and humidity. The interface between the housing and the core must be uniform and without voids. The strength of the bond shall be greater than the tearing strength of the polymer.

The manufacturer shall follow non-destructive technique (N.D.T.) to check the quality of jointing of the housing interface with the core. The technique being followed with detailed procedure and sampling shall be finalized during finalization of MQP.

The weather sheds of the insulators shall be of alternate shed profile as per IEC 60815- 3. The weather sheds shall be vulcanized to the sheath (extrusion process) or moulded as part of the sheath (injection moulding process) and free from imperfections. The vulcanization for extrusion process shall be at high temperature and for injection moulding shall be at high temperature & high pressure. Any seams / burrs protruding axially along the insulator, resulting from the injection moulding process shall be removed completely without causing any damage to the housing. The track resistance of housing and shed material shall be class 1A4.5 according to IEC60587**.** The strength of the weather shed to sheath interface shall be greater than the tearing strength of the polymer. The composite insulator shall be capable of high pressure washing.

End fittings shall be free from cracks, seams, shrinks, air holes and rough edges. End fittings should be effectively, sealed to prevent moisture ingress, effectiveness of sealing system must be supported by test documents. All surfaces of the metal parts shall be perfectly smooth with the projecting points or irregularities which may cause corona. All load bearing surfaces shall be smooth and uniform so as to distribute the loading stresses uniformly.

The hollow silicone composite insulators shall comply with the requirements of the IEC publications IEC 61462 and the relevant parts of IEC 62217. The design of the composite insulators shall be tested and verified according to IEC 61462 (Type & Routine test)

10.8. Clamps and fittings shall be of hot dip galvanised/stainless steel.

10.9. Bushing turrets shall be provided with vent pipes, to route any gas collection through the Buchholz relay.

10.10. No arcing horns shall be provided on the bushings.

10.11. Spare Bushing shall be specially packed to avoid any damage during transit and suitable for long storage, with non-returnable packing wooden boxes with hinged type cover. Without any gap between wooden planks. Packing Box opening cover with nails/screws type packing arrangement shall not be acceptable. In case of RIP bushing with polymer housing, Bushing oil end portion shall be fitted with metal housing with positive dry air pressure and a suitable pressure monitoring device shall be fitted on the metal housing during storage to avoid direct contact with moisture with epoxy. Alternatively, oil filled metal housing with suitable arrangement for taking care oil expansion due to temperature variations shall also be acceptable. Manufacturer shall submit drawing/ documents of packing for approval during detail engineering. Detail method for storage of bushing including accessories shall be brought out in the instruction manual.

10.12. The terminal marking and their physical position shall be as per IEC: 60076.

11. Neutral Formation and Earthing Arrangement

11.1. **For 3-Phase Unit**

The neutral of the transformer shall be brought out through bushing. The neutral terminal of 3-phase transformer shall be brought to the ground level by a brass/tinned copper grounding bar, supported from the tank by using porcelain insulators. The end of the brass/tinned copper bar shall be brought to the bottom of the tank, at a convenient point, for making bolted connection to two (2) copper flat conductor cable or stranded copper wire of minimum size (cross sectional area) 160sq. mm (shall be finalized exact size during detail engineering) that shall be connected to Substation grounding mat.

11.2. **For 1-Phase Unit**

The neutral of the transformer shall be brought out through bushing. The contractor shall connect the neutrals of 1-phase transformers by overhead connection using an overhead common brass/tinned copper/Aluminum pipe /ACSR conductor grounding bus, supported from the tank and fire walls by using porcelain insulators. All material like Bus post insulator, Aluminium tube, conductor, clamps & connectors, earthing materials, support structure, hardware etc required for neutral formation and connection with neutral CT and earthing of neutral shall be provided by contractor. The neutral formation shall be such that neutral winding of single-phase spare transformer can be disconnected or connected to either of the three phase banks.

12. Delta Formation (applicable for 1-Phase Transformer)

The tertiary/LV winding terminals of the transformer shall be brought out through bushing. The contractor shall connect Tertiary/LV of 1-phase transformers in DELTA configuration by overhead connection to operate in 3-Phase Bank. The Delta shall be formed by approximate size of 3" IPS Al tube, which shall be insulated with heat shrinkage insulating sleeve or cable of suitable voltage class and adequate thickness and shall be supported by structure mounted bus post insulators at suitable intervals. The minimum phase to phase horizontal spacing for delta formation shall be 1.5 meter. All associated materials like bus post insulators, Aluminium tube, clamps & connectors, support structures; hardware etc. required for tertiary delta formation shall be provided by the contractor.

13. Spare Unit connection arrangement (as applicable for 1-Phase Transformer)

Connection arrangement of spare unit of transformer with other units shall be made by isolator switching (Isolators are not part of this specification). Tertiary delta and neutral formation for spare unit of transformer shall be done by manual connection. The contractor shall make connection arrangement as well as control scheme of OLTC and Cooler in such a way that spare unit of transformer can be connected in place of faulty unit without physically shifting it from its location. For this purpose, HV, IV, Tertiary and Neutral Connections of spare unit are to be extended upto the other unit by forming auxiliary buses with tertiary connection insulated with heat shrinkage insulating sleeve of suitable voltage class and adequate thickness and shall be supported by structure mounted bus post insulators at suitable intervals to enable spare unit connection through flexible/rigid conductor and suitable connector in place of existing unit to be replaced. However, the detail configuration and actual sizes of various items shall be finalised during detailed engineering and shall be subject to Employer’s approval. All associated materials like Bus post insulators, Aluminium tube, conductors, clamps & connectors, insulator strings, hardware, cables, support structures, required for the above-mentioned arrangement shall be provided by the contractor.

14. Cooling Equipment and its Control

14.1. **Cooling Equipment for Radiator Bank**

14.1.1. The cooler shall be designed using radiator banks or tank mounted radiators. Design of cooling system shall satisfy the performance requirements.

14.1.2. In case of separately mounted radiator bank arrangement, the main tank shall have provision such that cooler banks can be placed on either side of the main tank without the need of any extra member/pipe maintaining the electrical clearances.

14.1.3. The radiator shall be of sheet steel in accordance with IS 513 and minimum thickness 1 mm. Each radiator bank shall be provided with the following accessories:

(a) Cooling Fans, Oil Pumps, Oil Flow Indicator (as applicable)
(b) Top and bottom shut off valve
(c) Drain Valve and sampling valve
(d) Top and bottom oil filling valves
(e) Air release plug
(f) Two grounding terminals for termination of two (2) copper flat conductor cable or stranded copper wire of minimum size (cross sectional area) 160sq. mm (shall be finalized exact size during detail engineering).
(g) Thermometer pockets with captive screw caps at cooler inlet and outlet.
(h) Lifting lugs

14.1.4. Each radiator bank shall be detachable and shall be provided with flanged inlet and outlet branches. Expansion joint shall be provided on top and bottom cooler pipe connection.

14.1.5. Required number of standby fans of approximately 20% capacity shall also be provided with each radiator bank.

14.1.6. Cooling fans shall not be directly mounted on radiator bank which may cause undue vibration. These shall be located so as to prevent ingress of rain water. Each fan shall be suitably protected by galvanised wire guard. The exhaust air flow from cooling fan shall not be directed towards the main tank in any case.

14.1.7. Two (2), 100% centrifugal or axial in line oil pumps, if applicable, (out of which one pump shall be standby) shall be provided with each radiator bank. Measures shall be taken to prevent mal-operation of Buchholz relay when all oil pumps are simultaneously put into service. The pump shall be so designed that upon failure of power supply to the pump motor, the pump impeller will not limit the natural circulation of oil.

14.1.8. An oil flow indicator shall be provided for the confirmation of the oil pump operating in a normal state. An indication in the flow indicator and potential free contacts for remote alarm shall be provided.

14.1.9. Valves shall be provided across the pump and oil flow indicator to avoid oil drain and long outage during maintenance / replacement of pump and oil flow indicator.

14.1.10. Cooling fans and oil pump motors shall be suitable for operation from 400 volts, three phase 50 Hz power supply and shall conform to IS: 325. Each cooling fan and oil pump motors shall be provided with starter thermal overload and short circuit protection. The motor winding insulation shall be conventional class 'B' type. Motors shall have hose proof enclosure equivalent to IP: 55 as per IS: 4691.

14.1.11. The cooler pipes, support structure including radiators and its accessories shall be hot dip galvanised or corrosion resistant paint should be applied to external surface of it.

14.1.12. Air release device and oil plug shall be provided on oil pipe connections. Drain valves shall be provided in order that each section of pipe work can be drained independently.

14.2. **Cooling Equipment Control for Radiator banks**

14.2.1. Automatic operation control of fans/pumps shall be provided (with temperature change) from contacts of winding temperature indicator. The Contractor shall recommend the setting of WTI for automatic changeover of cooler control over entire cooling option. The setting shall be such that hunting i.e. frequent start-up operations for small temperature differential do not occur.

14.2.2. Suitable manual control facility for cooler fans and oil pumps shall be provided. Selector switches and push buttons shall also be provided in the cooler control cabinet to disconnect the automatic control and start/stop the fans and pump manually.

14.2.3. The changeover to standby oil pump in case of failure of service oil pump shall be automatic.

14.2.4. In addition to the traditional starting of fan and pump by oil temperature, the starting of forced cooling shall be done if the load exceeds a current setting of 0.6 p.u. for 5 seconds. Furthermore, a one-week timer is required to check the healthiness of the cooling system on a routine basis for one hour at a time.

14.2.5. Following lamp indications shall be provided in cooler control cabinet:

a) Cooler Supply failure (main)
b) Cooler supply changeover
c) Cooler Supply failure (standby)
d) Control Supply failure
e) Cooling fan failure for each bank
f) Cooling pump failure for each pump
g) Common thermal overload trip

One potential free initiating contact for all the above conditions shall be wired independently to the terminal blocks of cooler control cabinet and for single ph. unit connection shall be extended further to CMB.

14.2.6. The cooler control cabinet / Individual Marshalling box shall have all necessary devices meant for cooler control and local temperature indicators. All the contacts of various protective devices mounted on the transformer and all the secondary terminals of the bushing CTs shall also be wired upto the terminal board in the cooler control cabinet/Individual Marshalling box. All the CT secondary terminals in the cooler control cabinet shall have provision for shorting to avoid CT open circuit while it is not in use.

14.2.7. All the necessary terminations for remote connection to Employer's panel shall be wired upto the Common Marshalling box.

14.2.8. The Contractor shall derive AC power for Cooler Control Circuitry from the AC feeder. In case auxiliary power supply requirement for Cooler Control Mechanism is different than station auxiliary AC supply, then all necessary converters shall be provided by the Contractor. Details of station auxiliary power supply are mentioned in GTR.

14.3. **Unit cooler arrangement for transformer (if applicable)**

14.3.1. The cooler shall be designed using Unit Cooler arrangement with capacity as specified in Annexure-A. Design of cooling system shall satisfy the performance requirements.

14.3.2. Each Unit Cooler shall have its own cooling fans, oil pumps, oil flow indicator, shut off valves at the top and bottom of at least 80 mm size, lifting lugs, top and bottom oil filling valves, air release plug at the top, a drain and sampling valve and thermometer pocket fitted with captive screw cap on the inlet and outlet.

14.3.3. An oil flow indicator shall be provided for the confirmation of the oil pump operating in a normal state. An indication shall be provided in the flow indicator to indicate reverse flow of oil/loss of oil flow.

14.3.4. Valves shall be provided across the pump and oil flow indicator to avoid oil drain and long outage during maintenance / replacement of pump and oil flow indicator.

14.3.5. Cooling fans and oil pump motors shall be suitable for operation from 400 volts, three phase 50 Hz power supply and shall conform to IS: 325/IEC34. Each cooling fan and oil pump motors shall be provided with starter thermal overload and short circuit protection. The motor winding insulation shall be conventional class 'B' type. Motors shall have hose proof enclosure equivalent to IP:55 as per IS:4691/IEC:34-5

14.3.6. The cooler, pipes, support structure and its accessories shall be hot dip galvanised or corrosion resistant paint should be applied to external surface of it.

14.3.7. Expansion joint shall be provided on top and bottom cooler pipe connections as per requirement.

14.3.8. Air release device and oil plug shall be provided on oil pipe connections. Drain valves shall be provided in order that each section of pipe work can be drained independently.

14.4. **Cooling Equipment Control (OFAF or ODAF) for Unit Coolers**

i) Suitable manual control facility for unit cooler shall be provided.

ii) The changeover to standby unit cooler bank oil pump in case of failure of any service unit cooler shall be automatic.

iii) Selector switches and push buttons shall also be provided in the cooler control cabinet to disconnect the automatic control and start/stop the unit cooler manually.

iv) Cooler fans & oil pumps of all unit coolers (except standby cooler) shall operate continuously. The starting of unit cooler shall be done as soon the Circuit Breaker of HV/IV/LV (as applicable) side is switched on.

v) Once started the cooling shall remain in operation as long as the transformer is in service. When the transformer is switched off the cooling shall continue to run for a further duration of 30 minutes. This timer shall be at least adjustable from 15 to 60 minutes. Further, a one-week timer is required to check the healthiness of the complete cooling system on a routine basis for one hour at a time. Spurious operation should however be avoided by appropriate settings. All settings shall be adjustable

vi) Adequate warning/ safety labels are required to indicate that the fans may start at any time.

vii) If any one group(s) is out of service and isolated, this shall not affect the automatic starting of the other unit cooler.

viii) Following lamp indications shall be provided in cooler control cabinet:
Cooler Supply failure (main)
Cooler supply changeover
Cooler Supply failure (standby)

Control Supply failure
Cooler unit failure for each unit cooler
No oil flow/reverse oil flow for pumps
Thermal overload trip for each fan / pump

One potential free initiating contact for all the above conditions shall be wired independently to the terminal blocks of cooler control cabinet and for single ph. unit connection shall be extended further to CMB.

14.5. **Auxiliary Power Supply for OLTC, Cooler Control and Power Circuit**

14.5.1. **For Single Phase unit**

14.5.1.1. Two auxiliary power supplies, 400 volt, three phase four (4) wire shall be provided at common marshalling box. All loads shall be fed by one of the two sources through an electrically interlocked automatic transfer scheme housed in the CMB. Power supply to individual phase unit shall be extended from the CMB. Power supply to spare unit shall be extended from nearest CMB only. Suitably rated power contactors, separate MCBs/MCCBs shall be provided in the Common Marshalling Box for each circuit.

14.5.1.2. For each circuit, suitably rated MCBs/MCCBs as required for further distribution of auxiliary power supply to DM boxes, Online Gases and moisture monitoring system, Online drying system and Fibre optic sensor Box etc.(as applicable), shall be provided by contractor, in individual marshalling boxes /cooler control boxes.

14.5.1.3. Auxiliary power supply distribution scheme shall be submitted for approval.

14.5.1.4. Supply and laying of Power, Control and special cables from common marshalling box to individual MB/Cooler Control Cubicle (including spare unit) & further distribution from IMB/CCC to all accessories is in the scope of the contractor. Further any special cable (if required) from CMB to Control Panels/Digital RTCC panels is also in the scope of the contractor.

14.5.1.5. Connection arrangement for spare unit shall be in such a way that spare unit of transformer can be connected in place of faulty unit without physically shifting and all the control, protection, indication signals of spare unit shall also be brought in common marshalling box of all the banks. Necessary arrangement in schematic of Common marshalling box is required to facilitate change-over of all the signals of faulty units to spare unit of Transformer, to ensure flow of control, protection and indication signals between Employer's Control panels / Digital RTCC Panel /SCADA and individual units under operation (i.e. any designated unit for bank or spare unit, if it replace any designated unit). To facilitate change-over of spare unit signals with faulty unit in CMB, male-female plug-in connector or better arrangement shall be provided to reduce the outage time.

14.5.2. **For Three Phase Transformer**

14.5.2.1. Two auxiliary power supplies, 400 volt, three phase four (4) wire shall be provided by the Employer at cooler control cabinet. All loads shall be fed by one of the two sources through an electrically interlocked automatic transfer scheme housed in the cooler control cabinet.

14.5.2.2. For each circuit, suitably rated power contactors, MCBs/MCCBs as required for entire auxiliary power supply distribution scheme including distribution to DM boxes, Online Gases and moisture monitoring system, Online drying system and Fibre optic sensor Box etc. (as applicable), shall be provided by contractor in cooler control cabinet.

14.5.2.3. Auxiliary power supply distribution scheme shall be submitted for approval. Supply and laying of Power, Control and special cables from marshalling box to all accessories is in the scope of the contractor. Further any special cable (if required) from MB to Control Panels/Digital RTCC panels is also in the scope of the contractor.

14.5.3. **Design features of the transfer scheme** shall include the following:

a) Provision for the selection of one of the feeder as normal source and other as standby.
b) Upon failure of the normal source, the loads shall be automatically transferred after an adjustable time delay to standby sources.
c) Indication to be provided at cooler control cabinet/Individual Marshalling Box/Common Marshalling Box for failure of normal source and for transfer to standby source and also for failure to transfer.
d) Automatic re-transfer to normal source without any intentional time delay following re-energization of the normal source.
e) Both the transfer and the re-transfers shall be dead transfers and AC feeders shall not be paralleled at any time.

14.6. **Valves**

14.6.1. All valves upto and including 100 mm shall be of gun metal or of cast steel/cast iron. Larger valves may be of gun metal or may have cast iron bodies with gun metal fittings. They shall be of full way type with internal screw and shall open when turned counter clock wise when facing the hand wheel. All hardware used shall be hot dip galvanised / stainless steel.

14.6.2. Suitable means shall be provided for locking the valves in the open and close positions. Provision is not required for locking individual radiator valves.

14.6.3. Each valve shall be provided with the indicator to show clearly the

Position (open/close) of the valve.

14.6.4. All valves flanges shall have machined faces.

14.6.5. All valves in oil line shall be suitable for continuous operation with transformer oil at 115 deg C.

14.6.6. The oil sampling point for main tank shall have two identical valves put in series. Oil sampling valve shall have provision to fix rubber hose of 10 mm size to facilitate oil sampling.

14.6.7. Valves or other suitable means shall be provided to fix various on line condition monitoring systems to facilitate continuous monitoring. The location & size of the same shall be finalized during detail design review.

14.6.8. **Flow sensitive conservator Isolation valve**

a) In order to restrict the supply of oil in case of a fire in transformer, flow sensitive valve shall be provided to isolate the conservator oil from the main tank.

b) A valve which shall be flow sensitive and shut off when the flow in the pipe is more than the flow expected in the permissible normal operating conditions. This valve shall be located in the piping between the conservator and the buchholz relay and shall not affect the flow of oil from and to the conservator in normal conditions.

c) When the flow from conservator to main tank is more than the normal operating conditions, the valve shall shut off by itself and will have to be reset manually. It shall be provided with valve open/close position indicator along with alarm contact indication in control room during closing operation of valve. This valve shall be provided with locking arrangement for normal position and oil filling / filtration position.

d) A suitable platform / ladder shall be provided to approach the valve for manual reset.

14.6.9. All valves shall be painted with a shade (preferably red or yellow) distinct and different from of main tank surface and as per the painting system and procedure specified.

15. Cabling

All interconnecting control and power cables between various parts of Transformers like turret CT, MBs, Fans, pumps, Buchholz, PRD etc. shall be routed through covered cable tray or GI conduit and shall be properly dressed.

All cables shall be armoured type. Un-armoured cables (if provided) in any circuitry, shall be through GI conduit and no part shall be exposed. Cable terminations shall be through stud type TB and ring type lugs. The Technical specification for cables is as per Chapter 12- Power and Control Cable. Contractor shall provide type tested cables from approved sources. No type testing for cables is envisaged. Both ends of all the wires (control & power) shall be provided with proper ferrule numbers for tracing and maintenance. Further, any special cables (if required) shall also be considered included in the scope. All cable accessories such as glands, lugs, cable tags/ numbers etc as required shall be considered included in the scope of supply.

16. Tap Changing Equipment

Each transformer shall be provided with Off load tap / On Load Tap changing equipment as specified elsewhere.

16.1. Off load tap Changer equipment (if applicable)

The off load / Off Circuit tap changer (OCTC) equipment shall be handle operated with a locking arrangement along with tap position indicator. The external handle shall be situated in an unobstructed position. The contacts are positively self-locating in each tapping position without constraint from the operating mechanism. The rating of the contacts shall be suitable to carry maximum current of the transformer. For three phase transformer the tap change switch shall simultaneous switch the similar taps on the three phases. A warning plate indicating that OCTC shall be operated only when the transformer is de-energised, shall be fitted.

16.2. ON Load Tap Changing (OLTC) Equipment

The On Load Tap Changer (OLTC) shall be of high speed resistor type with vacuum technology include the following:

16.2.1. Main OLTC Gear Mechanism

16.2.1.1. Each single / three phase transformer shall be provided with voltage control equipment of the tap changing type for varying its effective transformation ratio whilst the transformers are on load.

16.2.1.2. OLTC shall be motor operated suitable for local as well as remote operation. The diverter switch or arcing switch shall be designed so as to ensure that its operation once commenced shall be completed independently of the control relays or switches, failure of auxiliary supplies etc. To meet any contingency which may result in incomplete operation of the diverter switch, adequate means shall be provided to safeguard the transformer and its ancillary equipment. The current diverting contacts shall be housed in a separate vacuum interrupter chamber not communicating with the oil in main tank of the transformer. The contacts shall be accessible for inspection without lowering oil level in the main tank and the contacts shall be replaceable. Electrical arcing took place in a vacuum interrupter only.

16.2.1.3. Necessary safeguards shall be provided to avoid harmful arcing at the current diverting contacts in the event of operation of the OLTC gear under overload conditions of the transformer.

16.2.1.4. Tap changer shall be so mounted that bell cover of transformer can be lifted without removing connections between windings and tap changer.

16.2.2. **Local OLTC Control Cabinet (Drive Mechanism Box)**

Each transformer unit of OLTC gear shall have following features:

16.2.2.1. OLTC shall be suitable for manually handle operated and electrically motor operated. For local manual operation from Local OLTC Control cabinet (Drive Mechanism Box), an external handle shall be provided.

16.2.2.2. OLTC's Local control cabinet shall be mounted on the tank in accessible position. The cranking device/handle for manual operation for OLTC gear shall be removable and suitable for operation by a man standing at ground level. The mechanism shall be complete with the following:

- Mechanical tap position indicator which shall be clearly visible from near the transformer.
- A mechanical operation counter of at least five digits shall be fitted to indicate the number of operations completed and shall have no provision for resetting. Mechanical stops to prevent over-cranking of the mechanism beyond the extreme tap positions.
- The manual control considered as back up to the motor operated on load tap changer control shall be interlocked with the motor to block motor start-up during manual operation.
- The manual operating mechanism shall be labelled to show the direction of operation for raising the voltage and vice-versa.
- An electrical interlock to cut-off a counter impulse for reverse step change being initiated during a progressing tap change and until the mechanism comes to rest and resets circuits for a fresh position.

16.2.2.3. For electrical operation from local as well as remote, motor operated mechanism shall be provided. It shall not be possible to operate the electric drive when the manual operating gear is in use. It shall not be possible for any two controls to be in operation at the same time. Transfer of source in the event of failure of one AC supply shall not affect the tap changer. Thermal device or other means shall be provided to protect the motor and control circuit.

16.2.2.4. The Local OLTC Drive Mechanism Box shall house all necessary devices meant for OLTC control and indication. It shall be complete with the followings:

i. A circuit breaker/contactor with thermal overload devices for controlling the AC Auxiliary supply to the OLTC motor
ii. Emergency Push Button to stop OLTC operation
iii. Cubicle light with door switch
iv. provided with anti-condensation metal clad heaters to prevent condensation of moisture
v. Padlocking arrangement for hinged door of cabinet
vi. All contactors relay coils and other parts shall be protected against corrosion, deterioration due to condensation, fungi etc.
vii. The cabinet shall be tested at least IP 55 protection class.

16.2.2.5. All relays and operating devices shall operate correctly at any voltage within the limits specified in Chapter-GTR. In case auxiliary power supply requirement for OLTC DM Box is different than station auxiliary AC supply, then all necessary converters shall be provided by the Contractor.

16.2.2.6. Operating mechanism for on load tap changer shall be designed to go through one step of tap change per command only, until the control switch is returned to the off position between successive operations / repeat commands.

16.2.2.7. Limit switches shall be provided to prevent overrunning of the mechanism and shall be directly connected in the control circuit of the operating motor provided that a mechanical de-clutching mechanism is incorporated. In addition, a mechanical stop shall be provided to prevent over-running of the mechanism under any condition. An interlock to cut-out electrical control when it tends to operate the gear beyond either of the extreme tap positions.

16.2.2.8. OLTC local control cabinet shall be provided with tap position indication for the transformer. Drive Mechanism shall be equipped with a fixed resistor network capable of providing discrete voltage steps or provide 4-20mA transducer outputs for tap position indication in CMB (for single phase unit) and input to Digital RTCC/SCADA system.

16.2.2.9. 'Local-remote' selector switch shall be provided in the local OLTC control cabinet. In Local mode, all electrical commands from remote (i.e. from CMB, Digital RTCC, SCADA etc.) shall be cut-off/blocked. Electrical operations to change tap positions shall be possible by using raise/lower push buttons under local mode from DM Box. In remote mode electrical commands from CMB/ Digital RTCC/SCADA etc. shall be executed. The remote-local selector switch shall be having at-least two spare contacts per position.

16.2.2.10. Following minimum contacts shall be available in DM Box, which shall be wired to CMB for single phase unit. Further these contacts shall be wired to Digital RTCC panel:

a. INCOMPLETE STEP which shall not operate for momentary loss of auxiliary power.
b. OLTC motor overload protection
c. Supply to DM Motor fail
d. OLTC IN PROGRESS
e. Local / Remote Selector switch position
f. OLTC upper/lower limits reached

16.2.2.11. All relays, switches, fuses etc. shall be mounted in the OLTC local control cabinet and shall be clearly marked / labelled for the purpose of identification.

16.2.2.12. A permanently legible lubrication chart if required shall be fitted within the OLTC local control cabinet.

16.2.3. **OLTC Control from Common Marshalling Box (CMB)**

16.2.3.1. It shall be possible to monitor, control/operate, the OLTC of all the three 1-phase transformers of a transformer bank from Common Marshalling Box. The control and monitoring terminations of a spare transformer unit shall be brought to CMB. The necessary switching arrangement through male-female plug-in TB assembly shall be provided for replacing spare unit with any one of the faulty phase unit for monitoring & control from CMB.

16.2.3.2. 'Independent-combined-remote selector switch, raise/lower switch and emergency stop Push Button shall be provided in the common marshalling box for OLTC control.

16.2.3.3. When the selector switch is in independent position, the OLTC control shall be possible from individual Local OLTC Control Cabinet (DM Box) only.

16.2.3.4. In '**combined position'**, raise-lower switch (provided in the CMB), shall be used to operate for bank of three single phase transformers from CMB.

16.2.3.5. In **'remote position'** control of OLTC shall be possible from Digital RTCC/SCADA etc.

16.2.3.6. From CMB, the operation of OLTC shall be for 3-phases of transformer units without producing phase displacement. Independent operation of each single phase transformer from CMB/ Digital RTCC/SCADA will be prevented.

16.2.3.7. Following minimum **LED indications** shall be provided in CMB:

a. INCOMPLETE STEP
b. OLTC motor overload protection
c. Supply to DM Motor fail

d. OLTC IN PROGRESS
e. Local / Remote Selector switch positions of DM
f. OLTC upper/lower limits reached
g. 400V Main AC supply ON
h. 400V Standby AC supply ON

Following **contacts** shall be wired to TBs in CMB for further wiring to C & R Panels.

i. 400V Main AC supply Fail
j. 400V Standby AC supply Fail

Following **contacts** shall be wired to TBs in CMB for further wiring to digital RTCC Panel:

a. INCOMPLETE STEP
b. OLTC motor overload protection
c. Supply to DM Motor fail
d. OLTC IN PROGRESS
e. Local / Remote Selector switch positions of DM
f. OLTC upper/lower limits reached
g. 'Independent-combined-remote' selector switch positions of CMB

Further, OLTC Tap position Digital indications for all three 1-Ph Transformer units either separately or through selector switch shall be provided in CMB. The same shall also be wired to Digital RTCC Panel to display tap positions for all three 1-ph unit separately.

16.3. **Digital RTCC Panel**

16.3.1. The digital RTCC panel shall have Automatic Tap Changer control and monitoring relay with Automatic Voltage Regulating features (referred as **Digital RTCC relay**) to remotely control and monitor OLTC. The relay shall be offered from the manufacturer who has already supplied Digital RTCC relay, which is in operation for at-least 2 years for transformer OLTC application.

16.3.2. For new substation, the contractor shall provide Digital RTCC panel consisting of 2 Nos. Digital RTCC relays which shall be used to control 2 banks of transformers (i.e. 6 Nos. 1-Phase units or 2 Nos. 3-Phase units), unless otherwise specified elsewhere. Further, one spare Digital RTCC relay shall also be provided in the same panel.

For existing substations, the requirement of digital RTCC panel and relays are specified in Chapter 1-PSR/BPS. However, bidders are advised to get clarified about the availability of existing RTCC schemes /Digital RTCC relays to finalize matching digital RTCC relays requirements. The Digital RTCC relays envisaged for existing transformers shall be integrated for parallel operations. All required cables for the same shall be included in the scope.

16.3.3. Digital RTCC relay shall be microprocessor based adopting the latest state of the art design & technology with in-built large display for ease of programming and viewing. The unit supplied shall be field programmable so that in the event of change in transformer / location, it could be customized to site conditions without sending back to works. The programming shall be menu driven and easily configurable. If it is designed with draw out type modules, it should take care of shorting all CT inputs automatically while drawing out. The CT / VT ratio shall be field programmable and Relay shall display the actual HV Voltage and current considering suitable multiplying factors. The system shall be self-sufficient and shall not require any additional devices like parallel balancing module etc.

All Digital RTCC Relays shall be of same make for smooth integration of these relays for parallel operations of all transformers in the substation.

16.3.4. The digital RTCC Panel shall be provided with digital RTCC relay having Raise/Lower push buttons, Manual/ Automatic mode selection features, Master / Follower/ Independent/ Off mode selection features and emergency stop Push Button for control of OLTC. Touch screen option in the relay, instead of electrical push button/switch is also acceptable.

16.3.5. **In Manual Mode**: In this mode, power system voltage based automatic control from digital RTCC relay shall be blocked and commands shall be executed manually by raise/lower push buttons.

16.3.6. **In Auto Mode:** In Auto mode, digital RTCC relay shall automatically control OLTC taps based on power system voltage and voltage set points. An interlock shall be provided to cut off electrical control automatically upon recourse being taken to the manual control in emergency.

16.3.7. **Master / Follower/ Independent/ Off mode**

Master Position: If the selector switch is in master position, it shall be possible to control the OLTC units of other parallel operating transformers in the follower mode by operation from the master unit.

Follower Position: If the selector switch is in Follower position control of OLTC shall be possible only from panel where master mode is selected.

Independent Position: In independent position of selector switch, control of OLTC shall be possible only from the panel where independent mode is selected. Suitable interlock arrangement shall be provided to avoid unwanted/inconsistent operation of OLTC of the transformer

16.3.8. **Raise/Lower control:** The remote OLTC scheme offered shall have provision to raise or lower taps for the complete bank of three 1-phase transformers/3-Phase Transformers. Individual 1-phase OLTC operation shall not be possible from the remote control panel.

16.3.9. Digital RTCC relays shall communicate with SCADA using IEC 61850 protocols to monitor, parameterise & control the OLTC. Any software required for this purpose shall be supplied. The supplied software shall not have restriction in loading on multiple computers for downloading and analyzing the data. Software shall indicate the current overview of all measured parameters of the connected transformer in real time. The digital RTCC Relay shall have multiple selectable set point voltages and it shall be possible to select these set points from SCADA, with a facility to have the possibility of additional set points command from SCADA.

Communication between the Digital RTCC relays to execute the commands for parallel operation shall be implemented using required communication protocol. IEC- 61850 GOOSE messaging between Digital RTCC relays for OLTC parallel operation is not permitted. Suitable communication hardware shall be provided to communicate up to distance of 1km between digital RTCC relays. Scope shall also include communication cables between digital RTCC relays. Cables as required for parallel operation of OLTCs of all transformers (including existing transformers wherever required) from Digital RTCC relays shall be considered included in the scope of bidder.

16.3.10. The Digital RTCC relay shall have programmable Binary Inputs (minimum 7 Nos.) and Binary outputs (minimum 7 Nos.) for Employer's future use. It shall be possible to have additional module for Binary Input / output as well as Analogue input module depending upon requirement.

16.3.11. The relays shall ensure positive completion of lowering/raising of the OLTC tap, once the command is issued from the relay. "Step-by-Step" operation shall be ensured so that only one tap change from each tap changing pulse shall be effected. If the command remains in the "operate" position, lock-out of the mechanism is to be ensured.

16.3.12. Following minimum indications/alarms shall be provided in Digital RTCC relay either through relay display panel or through relay LEDs:

a. INCOMPLETE STEP alarm
b. OLTC motor overload protection alarm
c. Supply to DM Motor fail alarm
d. OLTC IN PROGRESS alarm
e. Local / Remote Selector switch positions in DM Box
f. OLTC upper/lower limits reached alarm

g. OLTC Tap position indications for transformer units
h. 'Independent-combined-remote selector switch positions of CMB

16.3.13. In case of parallel operation or 1-Phase Transformer unit banks OLTC out of step alarm shall be generated in the digital RTCC panel for discrepancy in the tap positions.

17. Constructional features of Cooler Control Cabinet/ Individual Marshalling Box/ Common Marshalling Box and Digital RTCC Panel

17.1. Each transformer unit shall be provided with local OLTC Drive Mechanism Box, cooler control cabinet /individual marshalling box. Digital RTCC panel and common marshalling (for a bank of three 1-phase units) shall be provided.

17.2. The cooler control cabinet, Individual Marshalling Box, Common Marshalling Box, shall be made of stainless steel sheet of at least 1.6 mm thick. Digital RTCC panel shall be CRCA sheet of minimum thickness of 2.5mm and shall be painted suitably as per **Annexure –E**.

17.3. The degree of protection shall be IP: 55 for outdoor and IP: 43 for indoor in accordance with IS: 13947/IEC: 60947.

17.4. All doors, removable covers and plates shall be gasketed all around with suitably profiled. All gasketed surfaces shall be smooth straight and reinforced if necessary to minimize distortion to make a tight seal. For Control cubicle / Marshalling Boxes etc. which are outdoor type, all the sealing gaskets shall be of EPDM rubber or any better approved quality, whereas for all indoor control cabinets / Digital RTCC panel, the sealing gaskets shall be of neoprene rubber or any better approved quality. The gaskets shall be tested in accordance with approved quality plan, IS: 1149 and IS: 3400.

17.5. Ventilating Louvers, if provided, shall have screen and filters. The screen shall be fine wire mesh of brass. All the control cabinets shall be provided with suitable lifting arrangement. Thermostat controlled space heater and cubicle lighting with ON-OFF switch shall be provided in each panel.

17.6. The size of Common marshalling box shall not be less than 1600mm (front) X 650mm (depth) X 1800mm (height). All the cabinets except common marshalling box & Digital RTCC shall be tank mounted. All the separately mounted cabinets and panels shall be free standing floor mounted type and have domed or sloping roof for outdoor application.

18. Fittings & accessories

The following fittings & accessories shall be provided with each transformer covered in this specification. The fittings listed below are not exhaustive and other fittings which are required for satisfactory operation of the transformer are deemed to be included.

a. Conservator for main tank with air cell, oil filling hole and cap, isolating valves, drain valve, magnetic oil level gauge with low & high level alarm contacts and dehydrating breather

b. Conservator for OLTC with drain valve, oil surge Relay, filling hole with cap, prismatic oil level gauge and dehydrating breather

c. Pressure relief devices

d. Sudden pressure relief relay

e. Buchholz relay double float, reed type with isolating valves on both sides, bleeding pipe with pet cock at the end to collect gases and alarm / trip contacts.

f. Air release plug

g. Inspection openings and covers

h. Bushing with metal parts and gaskets to suit the termination arrangement

i. Winding & Oil temperature indicators for local and remote mounting

j. Cover lifting eyes, transformer lifting lugs, jacking pads, towing holes and core and winding lifting lugs

k. Protected type mercury or alcohol in glass thermometer or magnetic or micro- switch type dial type temperature indicator

l. Bottom and top filter valves with threaded male adaptors, bottom sampling valve and drain valve

m. Rating and diagram plates (in Hindi & English) on transformers and auxiliary apparatus

n. On load tap changing gear, OLTC DM Box, Off Circuit Tap Changer (OCTC) individual marshalling box / Cooler control cabinet, Common Marshalling Box, Fibre optic sensor box and Digital RTCC Panel as applicable

o. Cooling equipment

p. Bushing current transformers

q. Oil flow indicator (if applicable)

r. Drain valves/plugs shall be provided in order that each section of pipe work can be drained independently

s. Terminal marking plates

t. Valves schedule plate

u. Ladder to climb up to the Transformer tank cover with suitable locking arrangement to prevent climbing during charged condition

v. Suitable Platform for safe access of Flow sensitive non-return valve and buchholz relay shall be provided, in case these are not accessible from transformer top.

w. Haulage lugs

x. On line insulating oil drying system

y. Online Dissolved Gas (Multi-gas) and Moisture Measuring Equipment (if specified in BPS)

z. On line dissolved Hydrogen and Moisture Measuring Equipment (if specified in BPS)

aa. Fibre optic sensor based temperature measuring system (for 400kV Transformer only)

bb. Flow sensitive conservator Isolation valve

cc. Flanged bi-directional wheels

dd. Nitrogen Injection Type Fire Prevention & Extinguishing System (if specified in BPS) as per **Annexure – K**

ee. Managed Ethernet switch, LIU patch cords etc. shall be provided in CMB/MB.

All IEC 61850 compliant signals from various monitoring equipment/accessories shall be wired upto the Ethernet switch.

19. Current Transformer

19.1. Current transformers shall comply with IEC-60044-1.

19.2. It shall be possible to remove the turret mounted current transformers from the Transformer tank without removing the tank cover. Necessary precautions shall be taken to minimize eddy currents and local heat generated in the turret.

19.3. Current transformer secondary leads shall be brought out to a weather proof terminal box near each bushing. These terminals shall be wired out to common marshalling box using separate cables for each core.

19.4. For 1-Phase Transformer, one number single phase current transformer (outdoor) for earth fault protection shall be provided for each bank of transformer and shall be located in the neutral conductor connecting common neutral point with earth.

19.5. Technical Parameters of Bushing CTs and Neutral CTs are enclosed at **Annexure – G.** The CT's used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection. Bushing Current transformer parameters indicated in this specification are tentative and liable to change within reasonable limits. The Contractor shall obtain Employer's approval before proceeding with the design of bushing current transformers.

19.6. Secondary resistance and magnetising current characteristics of TPS class (protection) (as per IEC) CT of same rating shall be identical. This is applicable for Neutral CT (outdoor) also and shall be reviewed during detail engineering.

20. Online Dissolved Gas (Multi-gas) and Moisture Measuring Equipment

Online Dissolved Gas (Multi-gas) and Moisture Measuring Equipment (if specified in BPS) along with all required accessories shall be provided with each transformer for measurement & analysis of dissolved gases and moisture in the oil. The detailed technical specification is enclosed at **Annexure-L**.

21. On Line Dissolved Hydrogen and Moisture Measuring Equipment

Online Dissolved Hydrogen and Moisture Measuring Equipment (if specified in BPS) along with all required accessories shall be provided with each transformer for monitoring of dissolved Hydrogen and moisture in the oil. The detailed technical is enclosed at **Annexure-M**.

22. On-line insulating oil drying system (Cartridge type)

On-line insulating oil drying system (Cartridge type) along with all required accessories shall be provided with each Transformer. The detailed technical specification is enclosed at **Annexure-N**.

23. Oil Storage Tank

23.1. Oil storage tank shall be of capacity as specified in BPS along with complete accessories. The oil storage tank shall be designed and fabricated as per relevant Indian Standards e.g. IS: 803 or other internationally acceptable standards. Transformer oil storage tanks shall be towable on pneumatic tyres and rested on manual screw jacks of adequate quantity & size. The tank shall be cylindrical in shape and mounted horizontally and made of mild steel plate of adequate thickness. Diameter of the tank shall be 2.0 meter approximately. The tank shall be designed for storage of oil at a temperature of 100 deg C.

23.2. The maximum height of any part of the complete assembly of the storage tank shall not exceed 4.0 metres above road top.

23.3. The tank shall have adequate number of jacking pad so that it can be kept on jack while completely filled with oil. The tank shall be provided with suitable saddles so that tank can be rested on ground after removing the pneumatic tyres.

23.4. The tank shall also be fitted with manhole, outside & inside access ladder, silica gel breather assembly, inlet & outlet valve, oil sampling valve with suitable adopter, oil drainage valve, air vent etc. Pulling hook on both ends of the tank shall be provided so that the tank can be pulled from either end while completely filled with oil. The engine capacity in horse power to pull one tank completely fitted with oil shall be indicated. Oil level indicator shall be provided with calibration in terms of litre so that at any time operator can have an idea of oil in the tank. Solenoid valve (Electro-mechanically operated) with Centrifugal pump shall be provided at bottom inlet so that pump shall be utilised both ways during oil fill up and draining. Suitable arrangement shall also be provided to prevent overflow and drain form the tank.

23.5. The following accessories shall also form part of supply along with each Oil storage tank:

i) Four numbers of 50NB suitable rubber hoses for transformer oil application up to temperature of 100 C, full vacuum and pressure up to 2.5 Kg/ cm2 with couplers and unions each not less than 10 metre long shall be provided.

ii) Two numbers of 100NB suitable for full vacuum without collapsing and kinking vacuum hoses with couplers and unions each not less than 10 metre long shall also be provided.

iii) One number of digital vacuum gauge with sensor capable of reading up to 0.001 torr, operating on 240V 50Hz AC supply shall be supplied. Couplers and unions for sensor should block oil flow in the sensor. Sensor shall be provided with at-least 8 meter cable so as to suitably place the Vacuum gauge at ground level.

23.6. The painting of oil storage tank and its control panel shall be as per technical specification.

23.7. The tank shall contain a self-mounted centrifugal oil pump with inlet and outlet valves, with couplers suitable for flexible rubber hoses and necessary switchgear for its control. There shall be no rigid connection to the pump. The pump shall be electric motor driven, and shall have a discharge of not less than 6.0 kl/hr. with a discharge head of 8.0m. The pump motor and the control cabinet shall be enclosed in a cubicle with IP-55 enclosure.

24. Oil Sampling Bottle

Oil sampling bottles (if specified in BPS) shall be suitable for collecting oil samples from transformers for Dissolved Gas Analysis. Bottles shall be robust enough, so that no damage occurs during frequent transportation of samples from site to laboratory.

Oil sampling bottles shall be made of stainless steel having a capacity of 1litre.Oil Sampling bottles shall be capable of being sealed gas-tight and shall be fitted with cocks on both ends.

The design of bottle & seal shall be such that loss of hydrogen shall not exceed 5% per week.

An impermeable oil-proof, transparent plastic or rubber tube of about 5 mm diameter, and of sufficient length shall also be provided with each bottle along with suitable connectors to fit the tube on to the oil sampling valve of the equipment and the oil collecting bottles respectively.

25. Oil Syringe

If specified in BPS, the glass syringe of capacity 50ml (approx) and three way stop cock valve shall be supplied. The syringe shall be made from Heat resistant borosilicate Glass. The material and construction should be resistant to breakage from shock and sudden temperature changes, reinforced at luer lock tip Centre and barrel base.

The cylinder-Plunger fitting shall be leak proof and shall meet the requirement of IEC- 60567. Plunger shall be grounded and fitted to barrel for smooth movement with no back flow. Barrel rim should be flat on both sides to prevent rolling and should be wide enough for convenient finger tip grip. The syringe shall be custom fit and uniquely numbered for matching. The syringe shall be clearly marked with graduations of 2.0 ml and 10.0 ml and shall be permanently fused.

26. Hand Tools

One set of hand tools **(if specified in BPS)** of reputed make packed in a carry bag/box broadly comprising of double ended spanners (open jaws, cranked ring, tubular with Tommy bar each of sizes 9mm to 24mm, one set each), adjustable wrenches (8 &12 inch one set), gasket punches (of different sizes used - one set), pliers (flat nose, round nose & side cutting one of each type), hammer with handle (one), files with handle (two), knife with handle (one), adjustable hacksaw (one), and cold chisel (one), bushing handling and lifting tools with nylon rope/belt, chain block (2 Nos.) and D-Shackle shall be supplied per Substation for which cost shall be deemed included.

27. Test Kit

- BDV Kit (if specified in BPS)as per **Annexure-H** of specification
- Portable DGA Kit (if specified in BPS)as per **Annexure-J** of specification

28. Inspection and Testing

The Contractor shall carry out a comprehensive inspection and testing programme during manufacture of the equipment. The inspection envisaged by the Employer is given below. This is however not intended to form a comprehensive programme as it is Contractor's responsibility to draw up and carry out such a programme in the form of detailed quality plan duly approved by Employer for necessary implementation.

28.1. Inspection

28.1.1. Tank and Conservator

a. Certification of chemical analysis and material tests of plates
b. Check for flatness
c. Electrical interconnection of top and bottom by braided tinned copper flexible
d. Welder's qualification and weld procedure
e. Testing of electrodes for quality of base materials and coatings
f. Inspection of major weld preparation
g. Crack detection of major strength weld seams by dye penetration test
h. Measurement of film thickness of:
    i. Oil insoluble varnish
    ii. Zinc chromate paint
    iii. Finished coat
i. Check correct dimensions between wheels, demonstrate turning of wheels through 90 degree and further dimensional check.
j. Check for physical properties of materials for lifting lugs, jacking pads, etc.

All load bearing welds including lifting lug welds shall be subjected to Non Destructive Testing.

k. Leakage test of the conservator
l. Certification of all test results

28.1.2. **Core**

a. Sample testing of core materials for checking specific loss, bend properties, magnetisation characteristics and thickness
b. Check on the quality of varnish if used on the stampings:
   i) Measurement of thickness and hardness of varnish on stampings
   ii) Solvent resistance test to check that varnish does not react in hot oil
   iii) Check overall quality of varnish by sampling to ensure uniform shining colour, no bare spots, no over burnt varnish layer and no bubbles on varnished surface
c. Check on the amount of burrs
d. Bow check on stampings
e. Check for the overlapping of stampings. Corners of the sheet are to be part.
f. Visual and dimensional check during assembly stage
g. Check for inter-laminar insulation between core sectors before and after pressing
h. Visual and dimensional checks for straightness and roundness of core, thickness of limbs and suitability of clamps
i. High voltage test (2 kV for one minute) between core and Yoke clamps, Yoke clamps to tank and Core to Tank
j. Certification of all test results

28.1.3. **Insulation Material**

a. Sample check for physical properties of materials
b. Check for dielectric strength
c. Visual and dimensional checks
d. Check for the reaction of hot oil on insulating materials
e. Dimension stability test at high temperature for insulating material
f. Tracking resistance test on insulating material
g. Certification of all test results

28.1.4. **Winding**

a. Sample check on winding conductor for mechanical properties and electrical conductivity
b. Visual and dimensional checks on conductor for scratches, dent marks etc.
c. Sample check on insulating paper for pH value, bursting strength and electric strength

d. Check for the reaction of hot oil on insulating paper
e. Check for the bonding of the insulating paper with conductor
f. Check and ensure that physical condition of all materials taken for windings is satisfactory and free of dust
g. Check for absence of short circuit between parallel strands
h. Check for brazed joints wherever applicable
i. Measurement of voltage ratio to be carried out when core/yoke is completely restacked and all connections are ready
j. Conductor enamel test for checking of cracks, leakage and pin holes
k. Conductor flexibility test
l. Heat shrink test for enamelled wire m. Certification of all test results

28.1.5. **Checks Before Drying Process**

a. Check condition of insulation on the conductor and between the windings.
b. Check insulation distance between high voltage connections, cables and earth and other live parts
c. Check insulating distances between low voltage connections and earth and other parts
d. Insulation of core shall be tested at 2 kV/minute between core and Yoke clamps, Yoke clamps to tank and Core to Tank
e. Check for proper cleanliness and absence of dust etc.
f. Certification of all test results

28.1.6. **Checks During Drying Process**

a. Measurement and recording of temperature, vacuum and drying time during drying process
b. Check for completeness of drying by periodic monitoring of dryness
c. Certification of all test results

28.1.7. **Assembled Transformer**

a. Check completed transformer against approved outline drawings, provision for all fittings, finish level etc.
b. Test to check effective shielding of the tank
c. Jacking test of Transformer in oil-filled condition (excluding separately mounted cooler bank)
d. Dye penetration test shall be carried out after the jacking test

28.1.8. **Bought Out Items**

The makes of all major bought out items shall be subject to Employer's approval for the following components:

a) Buchholz Relay
b) Axles and wheels

c) Winding temperature indicators for local and remote mounting
d) Oil temperature indicators
e) Bushings
f) Bushing current transformers
g) Cooler control cabinet/ Individual Marshalling box and common marshalling box as applicable
h) Cooling equipment
i) Oil pumps
j) Fans/Air Blowers
k) Tap change gear
l) Pressure relief device

The above list is not exhaustive and the Contractor shall also include other bought-out items in his programme.

28.2. **Factory Tests**

The manufacturer shall be fully equipped to perform all the required tests as specified. Bidder shall confirm the capabilities of the proposed manufacturing plant in this regard when submitting the bid. Any limitations shall be clearly stated in.

The contractor shall bear all additional costs related to tests which are not possible to carry out at his own works.

The contractor shall submit an Inspection and test plan (ITP) for approval. A typical test plan is indicated in "**Annexure-B".**

All tests shall be done in line with IEC: 60076 and the test procedures as mentioned in "**Annexure-B".** Complete test report shall be submitted to Employer after proper scrutiny and signing on each page by the test engineer of the contractor.

28.3. **Type Tests on fittings:**

All the following fittings shall conform to type tests and the type test reports shall be furnished by the contractor along with the drawings of equipment/ fittings as per the Chapter 2 – GTR:

1) Bushing (Type Test as per IEC: 60137 including Snap back/Seismic test for 400 kV and above voltage class bushing)

2) OLTC (Test as per IEC:60214 and IP-55 test on driving mechanism box)

3) Buchholz relay (Type Test as per IS: 3637 and IP-55 Test on terminal box)

4) Cooler Control cabinet, Individual Marshalling & common marshalling

box (IP-55 test)

5) Pressure Relief device Test

The pressure Relief Device of each size shall be subjected to increase in oil pressure. It shall operate before reaching the test pressure specified in transformer tank pressure test above. The operating pressure shall be recorded. The device shall seal off after excess pressure has been released.

The terminal box / boxes of PRD should conform to degree of protection of IS 13947/Equivalent IEC standard.

6) Sudden Pressure Relay Test

7) Magnetic Oil Level gauge & Terminal Box for IP-55 degree of protection.

8) Air Cell (Flexible air separator) - Oil side coating, Air side under Coating, Air side outer coating and coated fabric as per IS: 3400/ BS: 903/ IS: 7016

9) OTI & WTI

10) Oil pump

11) Cooling fan and motor assembly

28.4. **Pre-Shipment Checks at Manufacturer's Works**

28.4.1. Check for inter-changeability of components of similar transformers for mounting dimensions.

28.4.2. Check for proper packing and preservation of accessories like radiators, bushings, dehydrating breather, rollers, buchholz relay, fans, control cubicle, connecting pipes, conservator etc.

28.4.3. Check for proper provision for bracing to arrest the movement of core and winding assembly inside the tank.

28.4.4. Gas tightness test to confirm tightness and record of dew point of gas inside the tank. Derivation of leakage rate and ensure the adequate reserve gas capacity.

28.5. **Inspection and Testing at Site**

The Contractor shall carry out a detailed inspection and testing programme for field activities covering areas right from the receipt of material stage up to commissioning stage. An indicative programme of inspection as envisaged by the Employer is given below. However, it is contractor's responsibility to draw up and carry out such a programme duly approved by the Employer. Testing of oil sample at site shall be carried out as per specification.

28.6. **Receipt and Storage Checks**

28.6.1. Check and record condition of each package, visible parts of the transformer etc. for any damage.

28.6.2. Check and record the gas pressure in the transformer tank as well as in the gas cylinder.

28.6.3. Visual check for wedging of core and coils before filling up with oil and also check conditions of core and winding in general.

28.6.4. Check and record reading of impact recorder at receipt and verify the allowable limits as per manufacturer's recommendations.

28.7. **Installation Checks**

28.7.1. Inspection and performance testing of accessories like tap changers, cooling fans, oil pumps etc.

28.7.2. Check the direction of rotation of fans and pumps and Check the bearing lubrication.

28.7.3. Check whole assembly for tightness, general appearance etc.

28.7.4. Oil leakage test

28.7.5. Capacitance and tan delta measurement of bushing before fixing/connecting to the winding, contractor shall furnish these values for site reference.

28.7.6. Leakage check on bushing before erection.

28.7.7. Measure and record the dew point of gas in the main tank before assembly.

28.8. **Commissioning Checks**

28.8.1. Check the colour of silicagel in silicagel breather.

28.8.2. Check the oil level in the breather housing, conservator tanks, cooling system, condenser bushing etc.

28.8.3. Check the bushing for conformity of connection to the lines etc.,

28.8.4. Check for correct operation of all protection devices and alarms/trip :

i. Buchholz relay
ii. Excessive winding temperature
iii. Excessive oil temperature
iv. Low oil flow
v. Low oil level indication
vi. Fan and pump failure protection

28.8.5. Check for the adequate protection on the electric circuit supplying the accessories.

28.8.6. Check resistance of all windings on all steps of the tap changer. Insulation resistance measurement for the following:

i) Control wiring
ii) Cooling system motor and control
iii) Main windings
iv) Tap changer motor and control

28.8.7. Check for cleanliness of the transformer and the surroundings

28.8.8. Phase out and vector group test

28.8.9. Ratio test on all taps

28.8.10. Magnetising current test

28.8.11. Capacitance and Tan delta measurement of winding and bushing

28.8.12. Frequency response analysis (FRA).

28.8.13. DGA of oil just before commissioning and after 24 hours energisation at site.

28.8.14. Gradually put the transformer on load, check and measure increase in temperature in relation to the load and check the operation with respect to temperature rise and noise level etc.

28.8.15. Continuously observe the transformer operation at no load for at least 24hours.

28.8.16. Contractor shall prepare a comprehensive commissioning report including all commissioning test results and forward to Employer for future record.

Annexure – A

1.0 Technical Particulars / Parameters of Transformers (400/220/33 kV Auto Transformer)

Clause No.	Description	Unit	Technical Parameters	
1.1	Rated Capacity			
	HV	MVA	500	167
	IV	MVA	500	167
	LV (Tertiary) :Active + Reactive loading	MVA	1/3 RD of rated capacity of HV winding	
1.2	Voltage ratio (Line to Line)		400/220/33	
1.3	Single / Three Phase Design		3 (THREE)	1 (SINGLE)
1.4	Applicable Standard		IEC 60076	
1.5	Frequency	Hz	50	50
1.6	Cooling & Percentage Rating at different cooling		ONAN/ONAF/(OFAF or ODAF) : 60% / 80%/100% OR ONAN/ONAF1/ONAF2: 60% / 80%/100% OR OFAF (with 5 x 25% unit cooler)	
1.7	Type of Transformer		Constant Ohmic impedance type (Refer note 1)	
1.8	Impedance at 75 Deg C			
	HV - IV			
	Max. Voltage tap	%	10.3	
	Principal tap	%	12.5	
	Min. Voltage tap	%	15.4	
	HV - LV			
	Principal tap (minimum)	%	60.0	
	IV - LV			
	Principal tap (minimum)	%	45.0	
1.9	Tolerance on Impedance (HV-IV)	%	As per IEC	
1.10	Service		Outdoor	
1.11	Duty		Continuous	
1.12	Overload Capacity		IEC-60076-7	
1.13	Temperature rise over 50deg C ambient Temp			
i)	Top oil measured by thermometer	^{o}C	50	
ii)	Average winding measured by resistance method	^{o}C	55	
1.14	Windings			
i)	System Fault level			
	HV	kA	50	
	IV	kA	40	
	LV	kA	25	
ii)	Lightning Impulse withstand Voltage			

Clause No.	Description	Unit	Technical Parameters
	HV	kV_p	1300
	IV	kV_p	950
	LV	kV_p	250
	Neutral	kV_p	95
iii)	Switching Impulse withstand Voltage		
	HV	kV_p	1050
iv)	One Minute Power Frequency withstand Voltage		
	HV	kV_{rms}	570
	IV	kV_{rms}	395
	LV	kV_{rms}	95
	Neutral	kV_{rms}	38
v)	Neutral Grounding		Solidly grounded
vi)	Insulation		
	HV		Graded
	IV		Graded
	LV		Uniform
vii)	Tertiary Connection		Ungrounded Delta
viii)	Tan delta of winding	%	< 0.5
1.15	Vector Group (3 –ph) (unless specified differently elsewhere)		YNaOd11
1.16	Tap Changer		OLTC
i)	Tap Range & No. of steps		10% of HV variation in the step of 1.25%, 16 steps
ii)	Location of Tap changer		On the 220 kV side of the series winding
iii)	Design		Constant flux voltage variation type as per cl. 6.2 of IEC 60076 part-I
iv)	Tap control		Full capacity - on load tap changer suitable for group / independent, remote /local electrical and local manual operation and bi-directional power flow
1.17	Bushing		
i)	Rated voltage		
	HV	kV	420
	IV	kV	245
	LV	kV	52
	Neutral	kV	36
ii)	Rated current (Min.)		
	HV	A	1250
	IV	A	2000
	LV	A	3150
	Neutral	A	2000
iii)	Lightning Impulse withstand Voltage		
	HV	kV_p	1425

Clause No.	Description	Unit	Technical Parameters
	IV	kV_p	1050
	LV	kV_p	250
	Neutral	kV_p	170
iv)	Switching Impulse withstand Voltage		
	HV	kV_p	1050
	IV	kV_p	850
v)	One Minute Power Frequency withstand Voltage		
	HV	kV_{rms}	695
	IV	kV_{rms}	505
	LV	kV_{rms}	105
	Neutral	kV_{rms}	77
vi)	Minimum total creepage distances		
	HV	mm	10500
	IV	mm	6125
	LV	mm	1300
	Neutral	mm	900
vii)	Tan delta of bushings		
	HV	%	< 0.4
	IV	%	< 0.4
	LV	%	< 0.4
	Neutral		
viii)	Max Partial discharge level at U_m		
	HV	pC	10
	IV	pC	10
	LV	pC	10
	Neutral		-
1.18	Max Partial discharge level at $1.58 * U_r / \sqrt{3}$	pC	100
1.19	Max Noise level at rated voltage and at principal tap on full load and all cooling active	dB	80

Notes:

1. For parallel operation with existing transformer, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.
2. No external or internal Transformers / Reactors are to be used to achieve the specified
   a. HV/IV, HV/LV and IV/LV impedances.
3. Tan delta of Winding & Bushing shall be measured at ambient temperature. No temperature correction factor shall be applied.
4. The criteria for Transformer losses shall be "**Copper Loss (Load Loss) > Iron Loss (No Load Loss) > Cooler Loss (Auxiliary Loss)".**

2.0 Technical Particulars / Parameters of Transformers (400/220/33 kV Auto Transformer)

Clause No.	Description	Unit	Technical Parameters	
2.1	Rated Capacity			
	HV	MVA	315	105
	IV	MVA	315	105
	LV (Tertiary) : Active + Reactive loading	MVA	1/3 RD of rated capacity of HV	
2.2	Voltage ratio (Line to Line)		400/220/33	
2.3	Single / Three Phase Design		3 (THREE)	1 (SINGLE)
2.4	Applicable Standard		IEC 60076	
2.5	Frequency	Hz	50	50
2.6	Cooling & Percentage Rating at different cooling		ONAN/ONAF/(OFAF or ODAF): 60% / 80%/100% OR ONAN/ONAF1/ONAF2: 60%/80%/100% OR OFAF(with 5 x 25% unit cooler)	
2.7	Type of Transformer		Constant Ohmic impedance type	
2.8	Impedance at 75 Deg C			
	HV - IV			
	Max. Voltage tap	%	10.3	
	Principal tap	%	12.5	
	Min. Voltage tap	%	15.4	
	HV - LV			
	Principal tap (minimum)	%	60.0	
	IV - LV			
	Principal tap (minimum)	%	45.0	
2.9	Tolerance on Impedance (HV-IV)	%	As per IEC	
2.10	Service		Outdoor	
2.11	Duty		Continuous	
2.12	Overload Capacity		IEC-60076-7	
2.13	Temperature rise over 50deg C ambient			
i)	Top oil measured by thermometer	^{O}C	50	
ii)	Average winding measured by resistance	^{O}C	55	
2.14	Windings			
i)	System Fault level			
	HV	kA	63	
	IV	kA	40	
	LV	kA	25	
ii)	Lightning Impulse withstand Voltage			
	HV	kV_p	1300	
	IV	kV_p	950	
	LV	kV_p	250	
	Neutral	kV_p	95	

Clause No.	Description	Unit	Technical Parameters
iii)	Switching Impulse withstand Voltage		
	HV	kV_p	1050
iv)	One Minute Power Frequency withstand		
	HV	kV_{rms}	570
	IV	kV_{rms}	395
	LV	kV_{rms}	95
	Neutral	kV_{rms}	38
v)	Neutral Grounding		Solidly grounded
vi)	Insulation		
	HV		Graded
	IV		Graded
	LV		Uniform
vii)	Tertiary Connection		Ungrounded Delta
viii)	Tan delta of winding	%	< 0.5
2.15	Vector Group (3 –ph) (unless specified differently elsewhere)		YNaOd11
2.16	Tap Changer		OLTC
i)	Tap Range & No. of steps		10% of HV variation in the step of 1.25%, 16 steps
ii)	Location of Tap changer		On the 220 kV side of the series winding
iii)	Design		Constant flux voltage variation type as per cl. 6.2 of IEC 60076 part-I
iv)	Tap control		Full capacity - on load tap changer suitable for group / independent, remote /local electrical and local manual operation and bi-directional power flow
2.17	Bushing		
i)	Rated voltage		
	HV	kV	420
	IV	kV	245
	LV	kV	52
	Neutral	kV	36
ii)	Rated current (Min.)		
	HV	A	1250
	IV	A	1250
	LV	A	3150
	Neutral	A	2000
iii)	Lightning Impulse withstand Voltage		

Clause No.	Description	Unit	Technical Parameters
	HV	kV_p	1425
	IV	kV_p	1050
	LV	kV_p	250
	Neutral	kV_p	170
iv)	Switching Impulse withstand Voltage		
	HV	kV_p	1050
	IV	kV_p	850
v)	One Minute Power Frequency withstand		
	HV	kV_{rms}	695
	IV	kV_{rms}	505
	LV	kV_{rms}	105
	Neutral	kV_{rms}	77
vi)	Minimum total creepage distances		
	HV	mm	10500
	IV	mm	6125
	LV	mm	1300
	Neutral	mm	900
vii)	Tan delta of bushings		
	HV	%	< 0.4
	IV	%	< 0.4
	LV	%	< 0.4
	Neutral		
viii)	Max Partial discharge level at U_m		
	HV	pC	10
	IV	pC	10
	LV	pC	10
	Neutral		-
2.18	Max Partial discharge level at 1.58 * U_r /√3	pC	100
2.19	Max Noise level at rated voltage and at principal tap on full load and all cooling active	dB	80

Notes:

1. For parallel operation with existing transformer, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.
2. No external or internal Transformers / Reactors are to be used to achieve the specified
   b. HV/IV, HV/LV and IV/LV impedances.
3. Tan delta of Winding & Bushing shall be measured at ambient temperature. No temperature correction factor shall be applied.
4. The criteria for Transformer losses shall be "**Copper Loss (Load Loss) > Iron Loss (No Load Loss) > Cooler Loss (Auxiliary Loss)".**

Annexure -B

Test Plan

No.	Test	U_m ≤ 170kV	U_m 170kV
1.	Measurement of winding resistance	Routine	Routine
2.	Voltage ratio measurement	Routine	Routine
3.	Polarity test	Routine	Routine
4.	No-load loss and current measurement	Routine	Routine
5.	Magnetic balance test (for three phase Transformer only)	Routine	Routine
6.	Impedance and load loss measurement	Routine	Routine
7.	Measurement of insulation resistance & Polarization Index	Routine	Routine
8.	Measurement of insulation power factor and capacitance between winding and earth and Bushings	Routine	Routine
9.	Chopped wave lightning impulse test for the line terminals (LIC)	Type	Routine
10.	Full wave lightning impulse test for the line terminals (LI)	Routine	-
11.	Measurement of transferred surge on LV (Tertiary) as applicable due to HV lightning impulse and IV lighting impulse (as applicable)	Type	Type
12.	Switching impulse test for the line terminal (SI)	Type	Routine
13.	Line terminal AC withstand voltage test (LTAC)	Routine	Type
14.	Induced voltage withstand test (IVW)	Routine	-
15.	Applied voltage test (AV)	Routine	Routine
16.	Induced voltage test with PD measurement (IVPD)	Routine	Routine
17.	On-load tap changer test(Ten complete cycle before LV test)	Routine	Routine
18.	Gas-in-oil analysis	Routine	Routine
19.	Core assembly dielectric and earthing continuity test	Routine	Routine
20	Oil leakage test on transformer tank	Routine	Routine
21.	Appearance, construction and dimension check	Routine	Routine
22.	Short duration heat run test (Not Applicable for unit on which temperature rise test is performed)	Routine	Routine
23.	Measurement of no load current & Short circuit Impedance with 400 V, 50 Hz AC.	Routine	Routine
24.	Frequency Response analysis (Soft copy of test report to be submitted to site along with test reports)	Routine	Routine
25.	High voltage with stand test on auxiliary equipment and wiring after assembly	Routine	Routine
26	Tank vacuum test	Routine	Routine
27.	Tank pressure test	Routine	Routine
28.	Lightning impulse test for the neutral terminals (LIN)	Type	Type
29.	Temperature rise test	Type	Type
30.	Measurement of Zero seq. reactance (for three phase Transformer only)	Type	Type
31.	Measurement of harmonic level in no load current	Type	Type
32.	Measurement of acoustic noise level	Type	Type
33.	Measurement of power taken by fans and oil pumps (Not applicable for ONAN)	Type	Type
34.	Dynamic Short circuit withstand test (as per clause 3.13)	Type*	Type*

Note: All the test shall be done in line with IEC: 60076 and as per above. Type test shall be carried out at first unit manufactured against the letter of award (LOA) at each manufacturing Plant except Dynamic Short circuit withstand test which shall be carried out as per clause 3.13.

Annexure - C

Test Procedures

1. Core assembly dielectric and earthing continuity test

After assembly each core shall be tested for 1 minute at 2000 Volts between all yoke clamps, side plates and structural steel work (core to frame, frame to tank & core to tank).

The insulation of core to tank, core to yoke clamp (frame) and yoke clamp (frame) to tank shall be able to withstand a voltage of 2 kV (DC) for 1 minute. Insulation resistance shall be minimum 1 GΩ for all cases mentioned above.

2. Short term heat run test (Not Applicable for unit on which temperature rise test is performed)

In addition to the type test for temperature rise conducted on one unit, each cooling combination shall routinely be subjected to a short term heat run test to confirm the performance of the cooling system and the absence of manufacturing defect such as major oil flow leaks that may bypass the windings or core.

DGA samples shall be taken at intervals to confirm the gas evolution.

For ODAF or OFAF cooling, the short term heat run test shall be done with the minimum number of pumps for full load operation in order to shorten the temperature build up. Each short term heat run test is nevertheless expected to take about 3 hours.

For ODAF or OFAF cooled transformers an appropriate cross check shall be performed to prove the effective oil flow through the windings. For this purpose the effect on the temperature decay by switching the pumps off/ on at the end of the heat run should demonstrate the effectiveness of the additional oil flow. Refer to SC 12, 1984 CIGRE 1984 SC12-13 paper by Dam, Felber, Preiniger et al.

Short term heat run test may be carried out with the following sequence:

- Heat run test with pumps running but oil not through coolers.
- Raise temperature to 5 deg less than the value measured during temperature rise test.
- Stop power input and pumps for 6 minutes and observe cooling down trend Restart pumps and observe increased cooling trend due to forced oil flow

3. Temp. Rise Test as per IEC: 60076

Gas chromatographic analysis on oil shall also be conducted before, during and after this test and the values shall be recorded in the test report. The sampling shall be in accordance with IEC 60567. The temperature rise test shall be conducted at a tap for the worst combination of loading (3-Winding Loss) for the Top oil of the transformer.

3-Winding Loss = HV (Max MVA) + IV(Max MVA) + LV (Max MVA).

The Contractor before carrying out such test shall submit detailed calculations showing losses on various taps and for the three types of ratings of the transformer and shall recommend the combination that results in highest temperature rise for the test.

The Temperature rise type test results shall serve as a "finger print" for the units to be tested only with short term heat run test.

Oil sample shall be drawn before and after heat run test and shall be tested for dissolved gas analysis. Oil sampling to be done 2 hours prior to commencement of temperature rise test. Keep the pumps running for 2 hours before and after the heat run test. Take oil samples during this period. For ONAN/ONAF cooled transformers, sample shall not be taken earlier than 2 hours after shut down. The acceptance norms with reference to various gas generation rates shall be as per IEC 61181.

The DGA results shall generally conform to IEC/IEEE/CIGRE guidelines.

i. Test conditions for temperature rise test:

This test shall be generally carried out in accordance with IEC 60076-2.

For each cooling combination with cooler bank, tests shall be done on the maximum current tap for a minimum of 12 hours for ONAN/ONAF and 24 hours for ODAF or OFAF or ONAF2 with saturated temperature for at least 4 hours while the appropriate power and current for core and load losses are supplied.

The total testing time, including ONAN heating up period, steady period and winding resistance measurements is expected to be about 48 hours.

DGA tests shall be performed before and after heat run test and

DGA results shall generally conform to IEC/IEEE/CIGRE guidelines.

ii. Test records:

Full details of the test arrangements, procedures and conditions shall be furnished with the test certificates and shall include at least the following.

iii. General:

Employer's order number and transformer site designation. Manufacturer's name and transformer serial number.

Rating of transformer MVA Voltages and tapping range Number of phases Frequency Rated currents for each winding Vector Group

Cooling Type Measured no-load losses and load losses at 75° C. Altitude of test bay.

Designation of terminals supplied and terminals strapped.

iv. Top oil temperature rise test:

A log of the following quantities taken at a minimum of 30 minute intervals:

- Time
- Voltage between phases
- Current in each phase and total power Power in each phase and total power Ambient temperature
- Top oil temperature
- Cooler inlet and outlet oil temperatures
- Hot spot temperatures (make use of probes) (if applicable)
- Colour photographs of the four sides and top of the transformer together with the corresponding series of thermal images (colour) during starting and end of the test. It is also recommended to take thermal images 4 more times to take care of any unforeseen situation.

v. Winding temperature rise test

Record the 'cold' resistance of each winding and the simultaneous top oil and ambient air temperatures, together with the time required for the effect to disappear.

Record the thermal time constant of the winding.

Log the half-hourly readings of the quantities as for the top oil temperature rise test.

Provide a table of readings, after shut-down of power, giving the following information ;

a) Time after shut- down:
b) Time increment:
c) Winding resistance: At least 20 minutes reading
d) Resistance increment:

Provide a record of all calculations, corrections and curves leading to the determination of the winding temperatures at the instant of shut-down of power.

Record any action taken to remedy instability of the oil surge device during initiation of the oil circulating pumps.

Temperature measurements as per special probes or sensors (fibre optic) placed at various locations shall also be recorded.

4. Tank Tests

i. Oil Leakage Test

All tanks and oil filled compartments shall be completely filled with air or oil of a viscosity not greater than that of insulating oil conforming to IEC 60296 at the ambient temperature and subjected to a pressure equal to normal head of oil plus 35 kN/sq.m (5 psi) measured at the base of the tank. This pressure shall be maintained for a period of not less than 12 hours for oil and 1 hour for air during which no leakage shall occur.

ii. Vacuum Test

All transformer tanks shall be subjected to the specified vacuum. The tank designed for full vacuum shall be tested at an internal pressure of 3.33 KN/Sq.m absolute (25 torr) for one hour. The permanent deflection of flat plate after the vacuum has been released shall not exceed the values specified below:

Horizontal Length of flat plate (in mm)	**Permanent deflection (in mm)**
Up to and including 750	5.0
751 to 1250	6.5
1251 to 1750	8.0
1751 to 2000	9.5
2001 to 2250	11.0
2251 to 2500	12.5
2501 to 3000	16.0
Above 3000	19.0

iii. Pressure Test

All transformer tanks, its radiator, conservator and other fittings together or separately shall be subjected to a pressure corresponding to twice the normal head of oil or normal oil head pressure plus 35 KN/sq.m whichever is lower, measured at the base of the tank and maintained for one hour. The permanent deflection of flat plates after the excess pressure has been released shall not exceed the figure specified above for vacuum test.

5. Dynamic short circuit withstand test shall be carried out as per IEC 60076-5. Dynamic short circuit test shall be carried out in HV-IV combination at nominal & extreme tap positions. For LV winding, dynamic short circuit shall be carried out either on HV-LV or IV-LV combination, whichever draws higher short circuit current as per calculation. Type tests shall be carried out before short circuit test. Following shall also be conducted before and after Short Circuit test:

i) Dissolved gas analysis
ii) Frequency response analysis
iii) All routine tests

Detail test procedure shall be submitted by contractor & shall be approved before short circuit test.

6. Routine test on bushings shall be done as per IEC 60137

Annexure–D

Design Review Document

Sr. No.	Description
1.	Core and Magnetic Design
2.	Over-fluxing characteristics upto 1.7U_m
3.	Inrush-current characteristics while charging from HV & IV respectively.
4.	Winding and tapping design
5.	Short-circuit withstand capability including thermal stress for min. 2 Sec.
6.	Thermal design including review of localised potentially hot area.
7.	Cooling design
8.	Overload capability
9.	Eddy current losses
10.	Seismic design, as applicable
11.	Insulation co-ordination
12.	Tank and accessories
13.	Bushings
14.	Tap changers
15.	Protective devices
16.	Fans, pumps and radiators
17.	Sensors and protective devices– its location, fitment, securing and level of redundancy
18.	Oil and oil preservation system
19.	Corrosion protection
20.	Electrical and physical Interfaces with substation
21.	Earthing (Internal & External)
22.	Processing and assembly
23.	Testing capabilities
24.	Inspection and test plan
25.	Transport and storage
26.	Sensitivity of design to specified parameters
27.	Acoustic Noise
28.	Spares, inter-changeability and standardization
29.	Maintainability
30.	PRD and SPR (number & locations)
31.	Conservator capacity calculation
32.	Winding Clamping arrangement details with provisions for taking it "in or out of tank"
33.	Conductor insulation paper details
34.	Location of Optical temperature sensors
35.	The design of all current connections
36.	Location & size of the Valves

Painting Procedure

Annexure – E

PAINTING	Surface preparation	Primer coat	Intermediate undercoat	Finish coat	Total dry film thick-ness (DFT)	Colour shade
Main tank, pipes, conservator tank, oil storage tank& DM Box etc. (external surfaces)	Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40 m)	Epoxy high build Micaceous iron oxide (HB MIO) (75 m)	Aliphatic polyurethane (PU) (Minimum 50 m)	Minimum 155 m	RAL 7035
Main tank, pipes (above 80 NB), conservator tank, oil storage tank & DM Box etc. (Internal surfaces)	Shot Blast cleaning Sa 2 ½*	Hot oil proof, low viscosity varnish or Hot oil resistant, non- corrosive Paint	--	--	Minimum 30 m	Glossy white for paint
Radiator (external surfaces)	Chemical / Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40 m)	Epoxy base Zinc primer (30-40 m)	PU paint (Minimum 50 m)	Minimum 100 m	Matching shade of tank/ different shade aesthetically matching to tank
	contractor may also offer Radiators with hot dip galvanised in place of painting with minimum thickness of 40 m (min)					
Radiator and pipes up to 80 NB (Internal surfaces)	Chemical cleaning, if required	Hot oil proof, low viscosity varnish or Hot oil resistant, non- corrosive Paint	--	--	--	--

PAINTING	Surface preparation	Primer coat	Intermediate undercoat	Finish coat	Total dry film thick-ness (DFT)	Colour shade
Digital RTCC Panel	Seven tank process as per IS:3618 & IS:6005	Zinc chromate primer (two coats)	--	EPOXY paint with PU top coat or POWDER coated	Minimum 80 m / for powder coated minimum 100 m	RAL 7035 shade for exterior and Glossy white for interior
Control cabinet / Marshalling Box - No painting is required.						

Note: (*) indicates Sa 2 ½ as per Swedish Standard SIS 055900 of ISO 8501 Part-1.

Annexure – F

Unused inhibited Insulating Oil Parameters

SN	Property	Test Method	Limits
A	**Function**		
1a	Viscosity at 100degC	ISO 3104 or ASTM D445 or ASTM D7042	(Max.) 3 mm2/s
1b	Viscosity at 40degC	ISO 3104 or ASTM D445 or ASTM D7042	(Max.) 12 mm2/s
1c	Viscosity at -30degC	ISO 3104 or ASTM D445 or ASTM D7042	(Max.) 1800 mm2/s
2	Appearance	A representative sample of the oil shall be examined in a 100 mm thick layer, at ambient temperature	The oil shall be clear and bright, transparent and free from suspended matter or sediment
3	Pour point	ISO 3016 or ASTM D97	(Max.)- 40degC
4	Water content a) for bulk supply b) for delivery in drums	IEC 60814 or ASTM D1533	Max.) 30 mg/kg 40 mg/kg
5	Electric strength (breakdown voltage)	IEC 60156	(Min.)50 kV(new unfiltered oil) / 70 kV (after treatment)
6	Density at 20 deg C	ISO 3675 or ISO 12185 or ASTM D 4052	0.820 - 0.895 g/ml
7	Dielectric dissipation factor (tan delta) at 90 deg C	IEC 60247 or IEC 61620 Or ASTM D924	(Max) 0.0025
8	Negative impulse testing KVp @ 25 deg C	ASTM D-3300	145 (Min.)
9	Carbon type composition (% of Aromatic, Paraffins and Naphthenic compounds)	IEC 60590 and IS 13155 or ASTM D 2140	Max.Aromatic : 4 to12 % Paraffins : <50% & balance shall be Naphthenic compounds.
B	**Refining/Stability**		
1	Acidity	IEC 60590 and IS 13155 or ASTM D 2140	(Max) 0.01 mg KOH/g
2	Interfacial tension at 27degC	ISO 6295 or ASTM D971	(Min) 0.04 N/m

SN	Property	Test Method	Limits
3	Total sulphur content	BS 2000 part 373 or ISO 14596 or ASTM D 2622 or ISO 20847	0.05 % (Max.) (before oxidation test)
4	Corrosive sulphur	IEC 62535	Non-Corrosive on copper and paper
		ASTM D1275B	Non-Corrosive
5	Presence of oxidation inhibitor	IEC 60666 or ASTM D2668 or D4768	0.08% (Min.) to 0.4% (Max.) Oil should contain no other additives .Supplier should declare presence of additives, if any.
6	2-Furfural content	IEC 61198 or ASTM D5837	25 Microgram/litre (Max.)
C	**Performance**		
1	Oxidation stability -Total acidity -Sludge - Dielectric dissipation factor (tan delta) at 90degC	IEC 61125 (method c) Test duration 500 hour IEC 60247	 Max 0.3 mg KOH/g Max 0.05 % Max 0.05
2	Oxidation stability	ASTM D2112 (a)	220 Minutes (Min.)
D	**Health, safety and environment (HSE)**		
1	Flash point	ISO 2719	(Min.)135deg C
2	PCA content	BS 2000 Part 346	Max 3%
3	PCB content	IEC 61619 or ASTM D4059	Not detectable (Less than 2 mg/kg)
E	**Oil used (inhibited) for first filling, testing and impregnation of active parts at manufacturer's works shall meet parameters as mentioned below:**		
1	Break Down voltage (BDV)		70kV (min.)
2	Moisture content		5 ppm (max.)
3	Tan-delta at 90°C		0.005 (max)
4	Interfacial tension		0.04 N/m (min)
F	**Each lot of the oil shall be tested prior to filling in main tank at site for the following:**		
1	Break Down voltage (BDV)		70 kV (min.)
2	Moisture content		5 ppm (max.)
3	Tan-delta at 90°C		0.0025 (Max)
4	Interfacial tension		More than 0.04 N/m

SN	Property	Test Method	Limits
G	**After filtration & settling and prior to energisation at site oil shall be tested for following:**		
1	Break Down voltage (BDV)	IS: 1866 / IEC 60422	70 kV (min.)
2	Moisture content at hot condition		5 ppm (max.)
3	Tan-delta at 90°C		0.005 (Max)
4	Interfacial tension		More than 0.04 N/m
5	*Oxidation Stability	Test method as per IEC	
	a) Acidity	61125 method C,	0.3 (mg KOH /g) (max.)
	b) Sludge	Test duration: 500hour for inhibited oil	0.05 % (max.)
	c) Tan delta at 90 °C		0.05 (max.)
6	*Total PCB content		Not detectable (less than 2 mg/kg total)
	*** Separate oil sample shall be taken and test results shall be submitted within 45 days after commissioning for approval of Employer.**		

Annexure – G

1.0 Current Transformer Parameters (On each phase) for 3-ph 500MVA and 1-ph, 167 MVA, 400/220/33 kV Transformers

Description	**Current Transformer Parameters (Transformer)**		
	HV Side	**IV Side**	**Neutral Side**
(a) Ratio			
CORE 1	1600/1	1600/1	1600/1
CORE 2	1000/1	1600/1	
(b) Minimum knee point voltage or burden and accuracy class			
CORE 1	1600V, TPS	1600V, TPS	1600V, TPS
CORE 2	0.2 Class 30VA ISF≤5	0.2 Class 30VA ISF ≤ 5	
(c) Maximum CT Secondary Resistance			
CORE 1	4.0 Ohm	4.0 Ohm	4.0 Ohm
CORE 2	-	-	
(d) Application			
CORE 1	Restricted Earth Fault	Restricted Earth Fault	Restricted Earth Fault
CORE 2	Metering	Metering	
(e) Maximum magnetization current (at knee point voltage)			
CORE 1	25 mA	25 mA	25 mA
CORE 2	-	-	

NOTE:

i) For TPS class CT's, Dimensioning parameter "K", Secondary VA shall be considered 1.5 and 20 respectively. Class (for the relevant protection and duties) as per IEC 60185.

ii) Rated continuous thermal current rating shall be 200% of rated primary current.

iii) Parameters of WTI CT for each winding shall be provided by the contractor.

iv) For estimation of spares, one set of CTs shall mean one CT of each type used in transformer.

v) The CT used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection.

2.0 Current Transformer Parameters (on each phase) for 3-ph 315 MVA 400/220/33 kV Transformers)

Description	Current Transformer Parameters (Transformer)		
	HV Side	IV Side	Neutral Side
(a) Ratio			
CORE 1	1000/1	1000/1	1000/1
CORE 2	600/1	1000/1	
(b) Minimum knee point voltage or burden and accuracy class			
CORE 1	1000V, TPS	1000V, TPS	1000V, TPS
CORE 2	0.2 Class 30VA ISF≤5	0.2 Class 30VA ISF ≤ 5	
(c) Maximum CT Secondary Resistance			
CORE 1	2.5 Ohm	2.5 Ohm	2.5 Ohm
CORE 2	-	-	
(d) Application			
CORE 1	Restricted Earth Fault	Restricted Earth Fault	Restricted Earth Fault
CORE 2	Metering	Metering	
(e) Maximum magnetization current (at knee point voltage)			
CORE 1	60 mA	60 mA	60 mA
CORE 2	-	-	

NOTE:

i. For TPS class CT's, dimensioning parameter "K", Secondary VA shall be considered 1.5 and 20 respectively. Class (for the relevant protection and duties) as per IEC 60185.
ii. Rated continuous thermal current rating shall be 200% of rated primary current.
iii. Parameters of WTI CT for each winding shall be provided by the contractor.
iv. For estimation of spares, one set of CTs shall mean one CT of each type used in transformer.
v. The CT used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection.

ANNEXURE - H

Technical Specification of Transformer Oil BDV Test Set

Item	**Specification**
Functional Requirement	1. The instrument should be suitable for Automatic Measurement of Electrical Breakdown Strength of transformer oil as per relevant standards. 2. The test results should have repeatability, consistency in laboratory condition.
Test Output	0-100 kV (Rate of rise: 0.5 to 5KV/Sec)
Accuracy	± 1 kV
Resolution	0.1 KV
Switch off Time	≤ 1ms
Display/Control	LCD/Keypads.
Printer	Inbuilt/External
Measurement Programmes	Fully Automatic Pre-programmed/User programmed Test Sequences including as per latest IEC & other national/international standards.
Test Lead/ Accessories	One complete set of electrodes, gauge etc. compatible with the instruments should be provided for successfully carrying out the test in EMPLOYER S/S. Additionally all the required accessories, tools, drawing, documents should be provided for the smooth functioning of kit. Further hard carrying case (which should be robust/ rugged enough) for ensuring proper safety of the kit during transportation shall have to be provided.
Design/Engg.	The complete equipment along with complete accessories must be designed /engineered by Original Equipment Manufacturer.
Power Supply	It shall work on input supply variations, V: 230 ±10 %, f: 50 Hz ±5 % on standard sockets.
Operating Temperature	0 to +50 deg C
Relative humidity	Max. 90% non-condensing.
Protection/ Control	Against short circuit, over load, transient surges etc. Also the instrument should have facility of stopping automatically on power failure. Also the kit should have facility of HV chamber interlocking as well as zero start interlocking.
Display/Control	LCD/keypads.

Environment	The test kit shall be compatible for EMI/EMC/Safety environment requirement as per IEC.
Guarantee	Warranty/Guarantee Period: Min 01 year from the date of successful & complete commissioning at Employer sub-station. All the materials, including accessories, cables, laptops etc. are to be covered under warranty/guaranty period. If the kit needs to be shifted to supplier's works for repairs within warranty/guaranty period, suppliers will have to bear the cost of spares, software, and transportation of kit for repair at test lab / works.
Calibration Certificate	Unit shall be duly calibrated before supply and the date of calibration shall not be older than two month from the date of supply of Kit.
Training	Supplier shall have to ensure that the instrument is made user friendly. Apart from the detailed demonstration at site, the supplier shall also have to arrange necessary training to EMPLOYER engineers.
Commissioning, handing over the Instrument	Successful bidder will have to commission the instrument to the satisfaction of EMPLOYER. The instrument failed during the demonstration shall be rejected and no repairs are allowed.

ANNEXURE - I

1.1 KV GRADE POWER & CONTROL CABLES

1.1 All Power & Control cables shall be supplied from Employer's approved vendors.

1.2 Separate cables shall be used for AC & DC. Separate cables shall be used for DC1 & DC2.

1.3 At least one (1) core shall be kept as spare in each copper control cable of 4C, 5C or 7C size whereas minimum no. of spare cores shall be two (2) for control cables of 10 core or higher size.

1.4 The Aluminium/Copper wires used for manufacturing the cables shall be true circular in shape before stranding and shall be uniformly good quality, free from defects. All aluminium used in the cables shall be of H2 grade.

1.5 The fillers and inner sheath shall be of non-hygroscopic, fire retardant material, shall be softer than insulation and outer sheath shall be suitable for the operating temperature of the cable.

1.6 Progressive sequential marking of the length of cable in metres at every one metre shall be provided on the outer sheath of all cables.

1.7 Strip wire armouring method (a) mentioned in Table 5, Page-6 of IS: 1554 (Part 1) – 1988 shall not be accepted for any of the cables. For control cables only round wire armouring shall be used.

1.8 The cables shall have outer sheath of a material with an oxygen index of not less than 29 and a temperature index of not less than 250°C.

1.9 All the cables shall conform to fire resistance test as per IS: 1554 (Part - I).

1.10 The normal current rating of all PVC insulated cables shall be as per IS: 3961.

1.11 Repaired cables shall not be accepted.

1.12 Allowable tolerance on the overall diameter of the cables shall be plus or minus 2 mm.

1.13 **PVC Power Cables**

1.13.1 The PVC (70°C) insulated 1100V grade power cables shall be of FR type, C1 category, conforming to IS: 1554 (Part-I) and its amendments read along with this specification and shall be suitable for a steady conductor temperature of 70°C. The conductor shall be stranded aluminium. The Insulation shall be extruded PVC to type-A of IS: 5831. A distinct inner sheath shall be provided in all multi core cables. For multi core armoured cables, the inner sheath shall be of extruded PVC. The outer sheath shall be extruded PVC to Type ST-1 of IS:5831 for all cables.

1.14 **PVC Control Cables**

1.14.1 The 1100V grade control cables shall be of FR type C1 category conforming to IS: 1554 (Part-1) and its amendments, read along with this specification. The conductor shall be stranded copper. The insulation shall be extruded PVC to type A of IS: 5831. A distinct inner sheath shall be provided in all cables whether armoured or not. The over sheath shall be extruded PVC to type ST-1 of IS: 5831 and shall be grey in colour except where specifically advised by the Employer to be black.

1.14.2 Cores shall be identified as per IS: 1554 (Part-1) for the cables up to five (5) cores and for cables with more than five (5) cores the identification of cores shall be done by printing legible Hindu Arabic Numerals on all cores as per clause 10.3 of IS : 1554 (Part - 1).

STANDARD TECHNICAL DATA SHEET (1.1kV GRADE XLPE POWER CABLES)

SN	Description	Parameters	
1a	Cable Sizes	1 C x 630	3½ C x 300
b	Manufacturer's type designation	A2XWaY	A2XWY
2	Applicable standard	IS: 7098/PT-I/1988 & its referred specifications	
3	Rated Voltage(volts)	1100 V Grade	
4	Type & Category	FR & C1	FR & C1
5	Suitable for earthed or unearthed system	for both	
6	Continuous current rating when laid in air in a ambient temp. of 50 C and for maximum conductor temp. of 70 C of PVC Cables[For information only]	732	410
7	Rating factors applicable to the current ratings for various conditions of installation	As per IS-3961-Pt-II-67	
8	Short circuit Capacity		
a	Guaranteed Short Circuit Amp. (rms) KA for 0.12 sec duration at rated conductor temperature of 90 degree C, with an initial peak of 105 KA	45kA	45kA
b	Maximum Conductor temp. allowed for the short circuit duty (deg C.) as stated above	250°C	
9	Conductor		
a	Material	Stranded Aluminium as per Class 2 of IS : 8130	
b	Grade	H 2 (Electrolytic grade)	
c	Cross Section area (Sq.mm.)	630	300/150
d	Number of wires(No.) minimum	53	30/15
e	Form of Conductor	Stranded and compacted	Stranded compacted circular/sector
f	Direction of lay of stranded layers	Outermost layer shall be R.H lay & opposite in successive layers	
10	Conductor resistance (DC) at 20 °C per km-maximum	0.0469	0.1/0.206
11	Insulation		
a	Composition of insulation	Extruded XLPE as per IS-7098 Part(1)	
b	Nominal thickness of insulation(mm)	2.8	1.8/1.4
c	Minimum thickness of insulation	2.42	1.52/1.16
12	Inner Sheath		
a	Material	Extruded PVC type ST-2 as per IS-5831-84	
b	Calculated diameter over the laid up cores,(mm)	NA	52
c	Thickness of Sheath (minimum)mm	NA	0.6
d	Method of extrusion	NA	Pressure/Vacuum extrusion
13	Armour		
a	Type and material of armour	Al wire [H4 grade]	Gal. Steel wire
b	Direction of armouring	Left hand	
c	Calculated diameter of cable over inner sheath (under armour), mm	33.9	53.2
d	Nominal diameter of round armour wire (minimum)	2	2.5
e	Guaranteed Short circuit capacity of the armour for 0.12 sec at room temperature.	45kA	45kA

SN	Description	Parameters	
f	DC resistance at 20 ^{o}C (Ω/Km)	$	0.577
14	Outer Sheath	ST-2 & FR	ST-2 & FR
A	Material (PVC Type)	38.3	59.50
B	Calculated diameter under the sheath	1.72	2.36
C	Min. thickness of sheath(mm)	Min 29.0	Min 29.0
D	Guaranteed value of minimum oxygen index of outer sheath at 27 C	Min 250	Min 250
E	Guaranteed value of minimum temperature index at 21 oxygen index	Black	Black
f	Colour of sheath	$	$
15a	Nominal Overall diameter of cable	+2/-2 mm	
b	Tolerance on overall diameter (mm)	shall conform to IS 10418 and technical specification	
16	Cable Drums	1000/500	1000/500
a	Max./ Standard length per drum for each size of cable (single length) with ±5% Tolerance (mtrs)		
b	Non-standard drum lengths	Maximum one(1) non-standard lengths of each cable size may be supplied in drums only over & above the standard lengths as specified above.(if required for completion of project)	
17	Whether progressive sequential marking on outer sheath provided at1 meter interval 18	Yes	
18	Identification of cores		
a	colour of cores	As per IS 7098 Part(1)	
b	Numbering	NA	
19	Whether Cables offered are ISI marked	Yes	
20	Whether Cables offered are suitable for laying as per IS 1255	Yes	

$'- As per manufacturer design data

STANDARD TECHNICAL DATA SHEET - 1.1kV kV GRADE PVC POWER CABLES

SN	Description	Parameters					
1a	Cable Sizes	1 c x 150	3.5 cx70	3.5 cx 35	4 c x 16	4c x 6	2 c x 6
1b	Manufacturer's type designation	AYWaY	AYFY	AYFY	AYFY	AYWY	AYWY
2	Applicable standard	IS: 1554/PT-I/1988 & its referred standards					
3	Rated Voltage(volts)	1100 V grade					
4	Type & Category	FR & C1	FR & C1	FR & C1	FR & C1	FR & C1	FR & C1
5	Suitable for earthed or unearthed system	for both					
6	Continuous current rating when laid in air in a ambient temp. of 50oC and for maximum conductor temp. of 70 oC of PVC Cables[For information only]	202	105	70	41	24	28
7	Rating factors applicable to the current ratings for various conditions of installation:	As per IS-3961-Pt-II-67					
8	Short circuit Capacity						
a)	Short Circuit Amp. (rms)KA for 1 sec duration	11.2	5.22	2.61	1.19	0.448	0.448
b)	Conductor temp. allowed for the short circuit duty (deg C.)	160^0C					
9	Conductor						
a)	Material	STRANDED ALUMINIUM					
b)	Grade	H 2 (Electrolytic grade)					
c)	Cross Section area (Sq.mm.)	150	M-70 N-35	M-35 N-16	16	6	6
d)	Number of wires(No.)	as per Table 2 of IS 8130					
e)	Form of Conductor	Non-compacted Stranded circular	shaped conductor	shaped conductor	shaped conductor	Non-compacted Stranded circular	Non-compacted Stranded circular
f)	Direction of lay of stranded layers	Outermost layer shall be R.H lay & opposite in successive layer					
10	Conductor resistance (DC) at 20 oC per km-maximum	0.206	0.443/0.868	0.868/1.91	1.91	4.61	4.61
11	Insulation						
a)	Composition of insulation	Extruded PVC type A as per IS-5831-84					
b)	Nominal thickness of insulation(mm)	2.1	1.4/1.2	1.2/1.0	1.0	1.0	1.0
c)	Minimum thickness of insulation	1.79	1.16/0.98	0.98/0.8	0.8	0.8	0.8
12	Inner Sheath						
a)	Material	Extruded PVC type ST-I as per IS-5831-84					
b)	Calculated diameter over the laid up cores,(mm)	N.A	27.6	20.4	15.7	11.6	9.6
c)	Thickness of Sheath (minimum) mm	N.A	0.4	0.3	0.3	0.3	0.3
13	Armour	as per IS 3975/88					

SN	Description	Parameters					
a)	Type and material of armour	Al. Wire[H4 grade]	Gal. steel strip	Gal. steel strip	Gal. steel strip	Gal. steel wire	Gal. steel wire
b)	Direction of armouring	left hand					
c)	Calculated diameter of cable over inner sheath (under armour),mm	18	28.4	21	16.3	12.2	10.2
d)	Nominal diameter of round armour wire/strip	1.6 4	0.8 4	0.8 4	0.8	1.4	1.4
e)	Number of armour wires/strips	Armouring shall be as close as practicable					
f)	Short circuit capacity of the armour along for 1 sec-for info only	K x A√t (K Amp)(where A = total area of armour in mm^2& t = time in seconds), K=0.091 for Al & 0.05 for steel					
g)	DC resistance at 20 oC (Ω/Km)	0.44	2.57	3.38 4	3.99	3.76	4.4
14	Outer Sheath						
a)	Material (PVC Type)	ST-1& FR	ST-1& FR	ST-1& FR	ST-1& FR	ST-1& FR	ST-1& FR
b)	Calculated diameter under the sheath	21.2	30.1	22.6	17.9	15	13
c)	Min. thickness of sheath(mm)	1.4	1.56	1.4	1.4	1.4	1.24
d)	Guaranteed value of minimum oxygen index of outer sheath at 27oC	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0
e)	Guaranteed value of minimum temperature index at 21 oxygen index	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250
f)	colour of sheath	Black	Black	Black	Black	Black	Black
15a)	Overall diameter of cable	$					
b)	Tolerance on overall diameter (mm)	+2/-2 mm					
16	Cable Drums	shall conform to IS 10418 and technical specification					
a)	Max./ Standard length per drum for each size of cable (single length) with ±5% Tolerance (mtrs)	1000/500	1000/500	1000/500	1000/500	1000/500	1000/500
b)	Non standard drum lengths	Maximum one(1) non standard lengths of each cable size may be supplied in drums only over & above the standard lengths as specified above.(if required for completion of project)					
17	Whether progressive sequential marking on outer sheath provided	Yes					
18	Identification of cores						
a)	Colour of cores	Red	R,Y,Bl & Bk	R,Y,Bl& Bk	R,Y,Bl & Bk	R,Y,Bl & Bk	Red & Bk
b)	Numbering	N.A	N.A	N.A	N.A	N.A	N.A
19	Whether Cables offered are ISI marked	YES					
20	Whether Cables offered are suitable for laying as per IS 1255	YES					

$'- As per manufacturer design data

STANDARD TECHNICAL DATA SHEET - 1.1kV kV GRADE PVC CONTROL CABLES

SN	Description	Parameters							
1a	Cable Sizes	2 c x 2.5	3c cx 2.5	5c x 2.5	7 c x 2.5	10 c x 2.5	14 c x 2.5	19 c x 2.5	27 c x 2.5
1b	Manufacturer's type designation	YWY	YWY	YWY	YWY	YWY	YWY	YWY	YWY
2	Applicable standard	IS: 1554/PT-I/1988 & its referred standards							
3	Rated Voltage(volts)	1100 V grade							
4	Type & Category	FR & C1							
5	Suitable for earthed or unearthed system	for both							
6	Continuous current rating when laid in air in a ambient temp. of 50oC and for maximum conductor temp. of 70 oC of PVC Cables[For information only]	22	19	19	14	12	10.5	9.7	8
7	Rating factors applicable to the current ratings for various conditions of installation:	As per IS-3961-Pt-II-67							
8	Short circuit Capacity								
a)	Short Circuit Amp. (rms)KA for 1 sec duration	0.285	0.285	0.285	0.285	0.285	0.285	0.285	0.285
b)	Conductor temp. allowed for the short circuit duty (deg C.)	160^0C							
9	Conductor								
a)	Material	Plain annealed High Conductivity stranded Copper (as per IS 8130/84)							
b)	Grade	Electrolytic							
c)	Cross Section area (Sq.mm.)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
d)	Number of wires(No.)	as per Table 2 of IS 8130							
e)	Form of Conductor	Non-compacted Stranded circular shaped conductor							
f)	Direction of lay of stranded layers	Outermost layer shall be R.H lay							

SN	Description	Parameters							
10	Conductor resistance (DC) at 20 oC per km-maximum	7.41	7.41	7.41	7.41	7.41	7.41	7.41	7.41
11	Insulation								
a)	Composition of insulation	Extruded PVC type A as per IS-5831-84							
b)	Nominal thickness of insulation(mm)	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
c)	Minimum thickness of insulation	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
12	Inner Sheath								
a)	Material	Extruded PVC type ST-I as per IS-5831-84							
b)	Calculated diameter over the laid up cores,(mm)	7.2	7.8	9.7	10.8	14.4	15.9	18	22.1
c)	Thickness of Sheath (minimum)mm	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
13	Armour	as per IS 3975/99							
a)	Type and material of armour	Gal. Steel Wire							
b)	Direction of armouring	left hand							
c)	Calculated diameter of cable over inner sheath (under armour), mm	7.8	8.4	10.3	11.4	15	6.5	18.6	22.7
d)	Nominal diameter of round armour	1.4	1.4	1.4	1.4	1.6	1.6	1.6	1.6
e)	Number of armour wires/strips	Armouring shall be as close as practicable							
f)	Short circuit capacity of the armour along for 1 sec-for info only	0.05 x A√t (K Amp)(where A = total area of armour in mm2 & t = time in seconds)							
g)	DC resistance at 20 oC (Ω/Km) & Resistivity	As per IS 1554 Part (1), wherever applicable and IS 3975-1999							
14	Outer Sheath								
a)	Material (PVC Type)	ST-1& FR							
b)	Calculated diameter under the sheath	10.6	11.2	13.1	14.2	18.2	19.7	21.8	25.9
c)	Min.thickness of sheath(mm)	1.24	1.24	1.24	1.24	1.4	1.4	1.4	1.56
d)	Guaranteed value of minimum oxygen index of outer sheath at 27oC	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0

SN	Description	Parameters							
e)	Guaranteed value of minimum temperature index at 21 oxygen index	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250
f)	colour of sheath	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey
15a)	Overall diameter of cable	$							
b)	Tolerance on overall diameter (mm)	+2/-2 mm							
16	Cable Drums	shall conform to IS 10418 and technical specification							
a)	Max./ Standard length per drum for each size of cable (single length) with ±5% Tolerance (mtrs)	1000/500							
b)	Non standard drum lengths	Maximum one(1) non standard lengths of each cable size may be supplied in drums only over & above the standard lengths as specified above.(if required for completion of project)							
17	Whether progressive sequential marking on outer sheath provided								
18	Identification of cores	Yes							
a)	Colour of cores	R & Bk	R, Y & Bl	Red R,Y,Bl	Grey	Grey	Grey	Grey	Grey
b)	Numbering	N.A	N.A	N.A	Numerals in black ink				
19	Whether Cables offered are ISI marked	YES							
20	Whether Cables offered are suitable for laying as per IS 1255	YES							

$'- As per manufacturer design data

ANNEXURE - J

Technical Specification of Portable Dissolved Gas Analysis of Transformer Oil

<table>
<tr><th>S.No.</th><th>Particulars</th><th>Specification</th></tr>
<tr><td>01</td><td>Functional Requirement</td><td>The Portable Gas Chromatograph equipment to extract, detect, analyze and display the dissolved gases in transformer oil as specified in IEEE C 57-104-1991 and IEC 60559-1999.</td></tr>
<tr><td>02</td><td>Extraction of Gases</td><td>Gases shall be extracted from insulating oil either of the mercury free extraction method
• Shake test method as described in IEC-60567-2005-Annexure C
• Head space method
• Partial Degassing toepler pump method</td></tr>
<tr><td>03</td><td>Detection of Gases</td><td>The gases extracted as above shall be detected using either portable GC with TCD/FID/any other detector or using spectroscopic method. All the fault gases i.e. H2, CH4, C2H2, C2H4, C2H6, CO&CO2 concentrations shall be individually measured and displayed. It is preferable that instrument also displays N2 and O2 content individually. The minimum detection limits of the instrument shall be strictly met the requirement of IEC-60567-2005-Page No.81-clause 9.2, table-5.</td></tr>
<tr><td>04</td><td>Performance Parameters</td><td>
<table>
<tr><th>Gases</th><th>Minimum Detection Limits in ppm</th><th>Working Range in ppm</th><th>Accuracy</th></tr>
<tr><td>Hydrogen-H2</td><td>5</td><td>0-5000</td><td rowspan="4">+/- 2 ppm or +/- 5% whichever is greater</td></tr>
<tr><td>Hydrocarbons-CH4, C2H2, C2H4, C2H6</td><td>1</td><td>0-10000</td></tr>
<tr><td>Carbon Monoxide-CO</td><td>25</td><td>0-10000</td></tr>
<tr><td>Carbon dioxide-CO2</td><td>25</td><td>0-50000</td></tr>
</table>
</td></tr>
<tr><td>05</td><td>Power Supply</td><td>It shall be operated with AC single phase, 50 Hz +/-5%, 230 V +/- 10% supply. All power cable and necessary adaptors shall be provided by supplier.</td></tr>
</table>

S.No.	Particulars	Specification
05	Calibration	• Instrument shall have facility to perform calibration check using GAS-IN-OIL standards as well as calibration gas mixtures. This GAS-IN-OIL standard shall be prepared in syringes in accordance with IEC-60567-2005-Page No.35- clause 6.2. • The calibration shall be demonstrated by supplier at the time of installation/commissioning at our lab and EMPLOYER will provide only the insulating oil for testing. • All necessary requirements like Glass syringes, 3 way cock and any other consumable required for calibration check shall include in the scope of supply.
07	Instrument control and Data handling, Internal Memory	• In case laptop is essential for operating the instrument, it shall be of latest specification along with licensed preloaded OS and software as well as software for interpreting DGA results accordance with IEEE C 57-104-1991 and IEC 60559-1999 along with laptop with carrying case included • In case instrument is having in built control for all the functions. Data acquisitions and data storage, it shall have a facility for communication with computer for downloading the data from instrument via USB port. Licensed copy of the software required to download data to computer shall be provided. • Internal Memory can capable of store 15000 records, if inbuilt functions
08	General Conditions	All required items/instruments /spares/consumable /connecting cables/communicationcables/instruments/manuals/Certificates/training materials/original software/original licensed data//station operating software/education CD/DVDs that are essential to understand the basics and advanced gas chromatography and in parts/items that are essential to complete the supply, installation and commissioning the system required in the international standards ASTM-D-3612/2002 Method C / IEC-60567-05 shall be supplied to our laboratory in healthy condition and no extra cost.
09	Operating Temperature, Relative humidity & Dimensions	01. Temperature 0-40 Deg. Centigrade 02. 85% non-condensing 03. Portable
10	Receipt, Storage	It shall be the responsibility of the supplier to ensure proper receipt and storage before commissioning the kit.
11	Warranty	The entire test set up shall be covered on warranty for a period of one year from the last date of complete commissioning and taking over the test set up. If the kit needs to be shifted to suppliers' works for repairs, supplier will have to bear the cost of, spares, software, and transportation etc. of kit for repair at test lab/works.
13	Application Note	An application note/principle document from original manufacturer compliance with standard test method shall be submitted along with the kit.

S.No.	Particulars	Specification
14	Service Support	The supplier shall furnish the detailed organization structure of the service team, who has acquired qualification and regular training records from manufacturer. Mode of attending service calls shall be given in details.
15	Training	The supplier shall arrange complete training by an application scientist who acquired technical & academic capacity of the principle company in the premises of our Laboratory for a period of two working days. The required reading materials/CDs shall be arranged by the supplier.
16	Spares and consumables	All the necessary spares and consumables including carrier gas bottles if required, calibration gas mixture, septa, syringes, 3 way valves etc. to run the equipment for AMC period with sample load of around 500 samples per year shall be offered items and quantity wise.

ANNEXURE – K

Nitrogen Injection Type Fire Prevention & Extinguishing System

1.1 Nitrogen Injection Type Fire Protection System (NIFPS) shall be designed to prevent explosion of transformer/reactor tank and the fire during internal faults resulting from arc.

The system shall work on the principle of Drain & stir. On activation, it shall drain a pre-determined quantity of oil from the tank top through drain valve to reduce the tank pressure, isolate conservator tank oil and inject nitrogen gas at high pressure from the bottom side of the tank through inlet valves to create stirring action and reduce the temperature of oil below flash point to extinguish the fire. On operation, the quantity of oil removed from the tank shall be such that adequate amount of oil shall remain to cover active part (i.e. core coil assembly).

Electrical isolation of transformer shall be an essential pre-condition for activating the system.

1.2 Operational Controls

The system operation shall be fully automatic and activate from the required fire and other trip signals. In addition to automatic operation, remote operation from control room/ remote centre and local manual control in the fire extinguishing cubicle shall also be provided. System shall operate on following situations:

1.2.1 Prevention of transformer from explosion and fire

To prevent transformer from explosion and fire in case of an internal fault, signals given by operation of Electrical protection relays and tripping of circuit breaker of transformer and operation of either Buchholz relay or pressure relief valve (PRV) shall be used to activate the system. The exact logic for system activation shall be finalized during detailed engineering.

1.2.2 Prevention of transformer from fire

In case of fire, sensed by fire detectors, the system shall be activated only after electrical isolation of the transformer, confirmed by breaker trip. If the fire detection is not associated with any other fault, the system activation shall be only manual. Manual operation switch shall be provided in the control room with a cover to avoid accidental operation of it.

1.3 Operation of System

On receiving activation signal, the following shall take place:

i) Open the quick opening drain valve to drain the top layer oil
ii) Shut off the conservator isolation valve to prevent flow of oil from the Conservator tank to the main tank
iii) Open the Nitrogen regulator valve to inject Nitrogen into the transformer tank to create stirring of oil.

There shall be interlock to prevent activation of the system if the transformer is not electrically isolated.

There shall also be provision for isolating the system during maintenance and/or testing of the transformer.

1.4 Technical Particulars

The contractor shall be responsible for the design of the complete system and shall submit the drawings and design calculations for the number of fire detectors, pipe sizing of drain pipe and Nitrogen injection pipe, Nitrogen cylinder capacity, number of injection points, etc. and get approval from EMPLOYER.

Facility shall be provided to test the system when the transformer is in service, without actually draining the oil and injecting Nitrogen.

The Nitrogen regulator valve shall be designed in such a way that the Nitrogen shall not enter the transformer tank even in case of passing/ leakage of valve.

Owner shall provide two distinct station auxiliary DC feeders for control purposes. The system shall work on station DC supply with voltage variation defined in GTR .The control box of fire protection system shall have facility to receive these feeders for auto changeover of supply. It shall be the contractor's responsibility to further distribute power to the required locations. In case auxiliary DC power supply requirement is different than station auxiliary DC supply, then all necessary DC-DC converters shall be provided by the Contractor.
Following minimum indications and alarms shall be provided in the local cubicle as well as in the control box:-

- Nitrogen cylinder pressure indication - manometer with sufficient number of adjustable NO contacts
- Nitrogen cylinder pressure low
- Fire in Transformer/ Reactor Oil drain started
- Conservator oil isolation valve closed
- Nitrogen injection started
- DC supply fail
- Oil drain valve closed
- Gas inlet valve closed

1.5 Details of Supply of System Equipments and Other Related Activities:

The scope of supply shall include the following items and any other items required for safe and trouble free operation of the system.

i) Fire extinguishing cubicle with base frame and containing at least the following:

- Nitrogen gas cylinder of sufficient capacity with pressure regulator and manometer with sufficient number of adjustable NO contacts.
- Oil Drain Assembly including oil drain pipe extension of suitable size for connecting pipes to oil pit
- Mechanical release device for oil drain and nitrogen release
- Limit switches for monitoring of the systems
- Panel lighting
- Flanges on top of the panel for connecting oil drain and nitrogen injection pipes for transformer
- Back up pressure switch to operate nitrogen gas valve
- Pressure indicators for Nitrogen pressure of the cylinder and actual injection through Nitrogen regulator

ii) Control box to be installed in the control room of the station for monitoring system operation, automatic control and remote operation, with alarms, indications, switches, push buttons, audio signal, suitable for tripping and signalling.

iii) Required number of fire detectors to be located in strategic locations to be finalized during detailed engineering.

iv) All controls, alarms, panels, cables, cable trays (if required), junction boxes etc.

1.6 Under Ground Oil Storage Tank

Each transformer unit shall be provided with an underground oil storage tank. The oil storage tank shall have Non Corrosive, water proof, epoxy coated (from Inside) mild steel (minimum thickness 6 mm) to store drained out oil on operation of NIFPS. The tank shall be painted from outside as per **Annexure –E**. The total capacity of storage tank shall be at least 10% of transformer tank oil to avoid overflowing of oil considering that drained oil volume shall be around 10% of transformer tank oil. Necessary arrangement shall be made on underground storage tank so as to take out the drained oil from the tank for further processing and use. All the pipe and physical connection from transformer to oil pit shall be in the scope of contractor.

This storage tank shall be placed in the pit made of brick walls with PCC (1:2:4) flooring with suitable cover plates to avoid ingress of rain water. The design of tank and pit shall be finalised during detailed engineering.

1.7 Installation and pre-commissioning test

After installation the system pre-commissioning tests shall be carried out jointly with the Owner’s representative before the system is put in service.

1.8 NIFPS based on alternate proven technology shall also be acceptable.

ANNEXURE – L

Online Dissolved Gas (Multi-gas) and Moisture Analyser

1.1. Online Dissolved Gas (Multi-gas) and Moisture Analyser along with all required accessories shall be provided with each transformer for measurement & analysis of dissolved gases and moisture in the oil. Interpretations shall be as per IEC 60599-1999.

1.2. The equipment shall detect, measure and analyses the following gases:

Gases & Moisture Parameters	Typical Detection Range
H_2	5 – 5,000 ppm
CH_4	5 – 5,000 ppm
C_2H_6	5 – 5,000 ppm
C_2H_4	3 – 5,000 ppm
C_2H_2	1 – 3,000 ppm
CO	10 – 10,000 ppm
CO_2	20 – 30,000 ppm
O_2 (Optional)	500 – 25,000 ppm
H_2O	2 – 100 % RS should have facility for measurement of moisture in oil in ppm

1.3. The analyser should measure (not calculate) all above gases and should have 100% sensitivity. The equipment shall be capable of transferring data to sub-station automation system confirming to IEC 61850. Necessary interface arrangement shall be provided by the contractor for integration with automation system. The necessary type test report for such confirmation shall be submitted during detailed engineering.

1.4. Equipment shall havefacility to give SMS alert to at least three users whenever any fault gas violates the predefined limit.

1.5. Equipment should work on station auxiliary supply. In case other supply is required for the equipment then suitable converter shall be included. All the necessary power and control cables, communication cables, cable accessories as required shall be provided by the supplier.

1.6. Online DGA shall be installed out door on transformer in harsh ambient and noisy condition (Electromagnetic induction, Corona, and capacitive coupling). Equipment shall be mounted separately to avoid effect of vibration. Suitable arrangement shall be provided to support and protect the inlet and outlet piping arrangement.The equipment shall be suitable for proper operation in EHV substation (800kV) environment where switching takes place in the EHV/HV System. The suitable indications for power On, Alarm, Caution, normal operation etc. shall be provided on the front panel of the equipment. The equipment shall have IP55 Stainless Steelenclosure, suitable for 55°C ambient temperature and EMI and EMC compatibility.The Equipment must carry a minimum of two (2) years manufacturer's Warranty.

1.7. The equipment shall connect to the transformer's main body in two locations. One Connection is for the supply of oil from the transformer. Second connection is for the return of the oil to the transformer.The connecting oil lines must be of Stainless Steel rigid pipes or flexible hoses.

1.8. The equipment shall be able to measure gas concentration and when downloaded should immediately compare it with user selected alarm & caution level for immediate display. The sampling rate shall be selectable as 2 or 4 or 6 or 12 hours etc. The equipment shall have inbuilt memory to store these results for complete one year even if sampling is done at the lowest interval.

1.9. The Equipment must have an automatic Calibration facility at fixed intervals. For calibration if anything required including cylinder must be mounted with the Equipment.

1.10. The technical feature of the equipment shall be as under:

Accuracy	$\pm$ 10%
Repeatability	$\pm$3% to 10% depending upon gases
Oil temperature range	- 20^{0} C to + 120^{0} C
External Temp. Range	- 20^{0} C to + 55^{0} C (External temp range of 55^{0} C is important and should not be compromise due to Nepal (Terai Region) ambient & operating conditions.)
Humidity range	10 to 95 %
Operating Voltage	230 Vac; 50 Hz (±20% variation)
Communications	USB&IEC 61850 compliant

1.11. Software for fault indication and fault diagnostics shall include following: Fault indication:

i) IEEE, IEC or user configurable levels of dissolved gases
ii) Rate of change trending

Fault Diagnosis:

i) Key gases
ii) Ratios (Rogers, IEC. etc.)
iii) Duval's Triangle

1.12. The equipment shall be supplied with all necessary accessories required for carrying out DGA of oil sample complete in all respect as per the technical specification. The following shall be also form a part of supply.

i) Software
ii) Operation Manual (2 set for every unit),
iii) Software Manual and
iv) Compact disc giving operation procedures of Maintenance Manual & Trouble shooting instructions.

ANNEXURE - M

On Line Dissolved Hydrogen and Moisture Monitor

1.0 The Monitor shall be a microprocessor based Intelligent Electronic Device (IED), designed to continuously detect and measure dissolved Hydrogen and Water content, even at very low concentrations, in Transformer Oil. It should be easy to install and it should be possible to retrofit it on an energized transformer, without shutting down the transformer.

2.0 The monitor shall be designed for permanent outdoor use in high voltage sub-station environments, for ambient temperatures of -20 deg C to 55 deg C and oil temperatures of -20 deg C to 105 deg C.

3.0 The monitor shall be suitable to detect and measure dissolved Hydrogen in ppm, without significant interference from other fault and atmospheric gases. The monitor shall also be suitable to detect Water Content measured in ppm or % RS (Relative Saturation).

4.0 Equipment shall be mounted separately to avoid effect of vibration. Suitable arrangement shall be provided to support and protect the inlet and outlet piping arrangement.The equipment shall be suitable for proper operation in EHV substation (800kV) environment where switching takes place in the EHV/HV System.

5.0 The Hydrogen sensors shall have long lifetime in oil. The sensors shall be able to withstand pressure from vacuum to 10 psi.

6.0 Technical Parameters:

Sr. No.	**Parameters**	**Requirements**
a)	The measurement range / Output:	
	Hydrogen Dissolved in oil	0 to 2000 ppm, with 4 – 20 mA output
	Water Dissolved in oil	0 to 95% RS, with 4 – 20 mA output
b)	Alarms/Indication (High & Very High)	
	Hydrogen	Programmable NO/NC contacts,
	Water	Programmable NO/NC contacts,
c)	Environment	
	Operating Ambient Temperature	– 20 to + 55 deg C
	Operating Oil Temperature	– 20 to + 105 deg C
d)	Pressure Withstand, (Oil side)	Full Vacuum to 10 psi.
e)	Exterior enclosure and components	made of corrosion proof material to IP -
f)	Communications	RS–232 ports and suitable for Ethernet connectivity

ANNEXURE - N

On-line insulating oil drying system (Cartridge type)

In addition to provision of air cell in conservators for sealing of the oil system against the atmosphere, each transformer shall be provided with an on line insulating oil drying system of adequate rating with proven field performance.

Equipment shall be mounted separately to avoid effect of vibration. Suitable arrangement shall be provided to support and protect the piping arrangement. The equipment shall be suitable for proper operation in EHV substation (800kV) environment where switching takes place in the EHV/HV System. This on line insulating oil drying system shall be

i. Designed for very slow removal of moisture that may enter the oil system or generated during cellulose decomposition. Oil flow to the equipment shall be controlled through pump of suitable capacity.

ii. The equipment shall display the moisture content in oil (PPM) of the inlet and outlet oil from the drying system.

iii. Minimum capacity of moisture extraction shall be 10 Litres before replacement of cartridge. Calculation to prove the adequacy of sizing of the on line insulating oil drying system along with make and model shall be submitted for approval of Employer during detail engineering.

The equipment shall be supplied with Operation Manual (2 set for every unit), Software (if any), and Compact disc giving operation procedures of Maintenance Manual & Trouble shooting instructions.

CHAPTER 6- TECHNICAL SPECIFICATION FOR SHUNT REACTOR (UPTO 400kV)

1. General

This specification covers design, engineering, manufacture, testing, delivery at site including all materials, accessories, spares, unloading, handling, proper storage at site, erection, testing and commissioning of the equipment specified.

2. Type of Reactor

The shunt reactor shall be of either gapped core type or magnetically shielded air core type (shell type) construction. The impedance ratio (X0/X1) specified shall be achieved by any one of the following methods:

i) Adopting single phase construction in separate tanks.
ii) Adopting 5 limb core construction, for 3-Phase

In case of coreless construction following requirements are stipulated.

i) A magnetic shield shall be provided around the coreless coils.
ii) Non-magnetic material sheet shall form the central core to minimize the vibrations.

3. Transportation

3.1. The Contractor shall be responsible to select and verify the route, mode of transportation and make all necessary arrangement with the appropriate authorities for the transportation of the equipment. The dimension of the equipment shall be such that when packed for transportation, it will comply with the requirements of loading and clearance restrictions for the selected route. It shall be the responsibility of the contractor to coordinate the arrangement for transportation of the Reactor for all the stages from the manufacturer's work to site.

3.2. The contractor shall carry out the route survey along with the transporter and finalise the detail methodology for transportation of reactor and based on route survey, any modification/ extension/ improvement to existing road, bridges, culverts etc. if required, shall be in the scope of the bidder.

3.3. The main tank of the reactor shall be inland transported on trailers equipped with GPS system for tracking the location of Reactor at all times during transportation from manufacturer works to designated site. The contractor shall intimate to Employer about the details of transporter engaged for transportation of the Reactor. The requisite details for tracking the Reactor during transit shall be provided to Employer. Requirement of Hydraulic trailer is envisaged for 400kV Shunt Reactor.

3.4. All metal blanking plates and covers, which are specifically required to transport the reactor, shall be considered part of the reactor and handed over to the Purchaser after completion of the erection. Bill of quantity of these items shall be included in the relevant drawing/document.

3.5. The Contractor shall despatch the reactor filled with dry air at positive pressure. The necessary arrangement shall be ensured by the contractor to take care of pressure drop of dry air during transit and storage till completion of oil filling during erection. A dry air pressure testing valve with necessary pressure gauge and adaptor valve shall be provided. The total duration of storage at site with dry air, shall preferably be limited to three months after which the Reactor shall be processed and filled with oil. The dry air cylinder(s) provided to maintain positive pressure can be taken back by the contractor after oil filling.

In case turret, having insulation assembly, is transported separately then positive dry air pressure shall be ensured.

3.6. Reactor shall also be fitted with sufficient number of Electronic impact recorders (on returnable basis) during transportation to measure the magnitude and duration of the impact in all three directions. The acceptance criteria and limits of impact, which can be withstood by the equipment during transportation and handling in all three directions, shall not exceed "3g" for 50mSec (20Hz) or as per contractor standard whichever is lower.

4. Performance

4.1. Shunt Reactors will be connected to the transmission system for reactive compensation and shall be capable of controlling the dynamic over voltage occurring in the system due to load rejection.

4.2. Shunt Reactors of 420kV Class shall be capable of operating continuously at a voltage 5% higher than their rated voltage without exceeding winding hot spot temperature 140 Deg Celsius. Maximum ambient temperature shall be considered as 50 Deg C.

4.3. Shunt Reactors of 245kV Class and below shall be capable of operating continuously at a voltage 10% higher than their rated voltage without exceeding winding hot spot temperature 140 Deg Celsius. Maximum ambient temperature shall be considered as 50 Deg C.

4.4. The reactor shall be designed to withstand the following over voltages repeatedly without risk of failure:

1.05Ur for continuous (for 420kV Class Reactor)
1.10Ur for continuous (for below 420kV Class Reactor)
1.25Ur for 1 minute
1.50 Ur for 5 seconds

4.5. The winding hot spots shall be calculated using the maximum localized losses, insulation thickness at the maximum loss positions, and the oil flow patterns in the winding. The oil temperature rise in the windings shall be used to determine hot spots rather than the bulk top oil temperature. The hot spot for all leads shall be calculated and it shall not exceed the calculated hot spot of the windings.

4.6. The hot spot temperatures and surface temperatures in the magnetic circuit (core) shall be calculated with maximum allowed 125 deg C and 120 deg C respectively under over voltage conditions specified above.

4.7. Also, the most onerous temperature of any part of the core and its supporting structure in contact with insulation or non-metal material shall not exceed the safe operating temperature of that material. Adequate temperature margins shall be provided to maintain long life expectancy of these materials.

4.8. Tank hotspot temperature under over voltage condition specified above shall not exceed 130 Deg C considering maximum ambient temperature as 50 Deg C.

4.9. The reactors shall be designed for switching surge overvoltage of 2.5 p.u. and temporary overvoltage of the order of 2.3 p.u. for few cycles followed by power frequency overvoltage upto 1.5 p.u. The reactor must withstand the stress due to above transient dynamic conditions which may cause additional current flow as a result of changed saturation characteristics/slope beyond 1.5 p.u. voltage.

4.10. The magnetic circuit will be designed such that the reactor is linear upto voltage specified at **Annexure – A**.

4.11. **Radio Interference and Noise Level**

4.11.1. The reactor shall be designed with particular attention to the suppression of harmonic voltage, especially the third and fifth so as to minimize interference with communication circuit.

4.11.2. The noise level of reactor, when energized at rated voltage and frequency shall not exceed the values specified at **Annexure-A** measured under standard conditions as defined in IEC.

5. Measurable Defects

The following shall constitute as Measureable Defects for the purpose of Defect Liabilities as per relevant clauses of GCC / SCC of the bidding document:

a) Repair, inside the Reactor either at site or at factory is carried out after commissioning.

b) The concentration of any fault gas is more than values of condition-1 indicated in clause no 6.5 of IEEE-C57.104-2008, which are given below:

H2	CH4	C2H2	C2H4	C2H6	CO	CO2	TDCG
100	120	1	50	65	350	2500	720

c) The winding Tan delta goes beyond 0.005 or increase more than 0.001 within a year w.r.t. pre-commissioning values. No temperature correction factor shall be applicable.

d) The moisture content goes above 12 ppm at any temperature during operation.

6. Design review

6.1. The reactor shall be designed, manufactured and tested in accordance with the best international engineering practices under strict quality control to meet the requirement stipulated in the technical specification. Adequate safety margin w.r.t. thermal, mechanical, dielectric and electrical stress etc. shall be maintained during design, selection of raw material, manufacturing process etc. in order to achieve long life of reactor with least maintenance.

6.2. Raw material and sub-vendors used by reactor manufacturer shall be declared before commencement of manufacturing. The validity of Type tests of Reactor shall be 10 years as on the originally scheduled date of bid opening, provided that offered reactor rating and design is identical to the type tested Reactor and same active materials (CRGO, Conductor and Insulation) of same grade & from the same sub-vendors are used. In case of any change of either active materials or sub-vendors, the type tests shall be carried out by the contractor at no extra cost to EMPLOYER. Type test report of Reactor manufacturing from the same manufacturing plant shall only be acceptable.

6.3. Design reviews shall be conducted by Purchaser or by an appointed consultant during the procurement process for Reactors; however the entire responsibility of design shall be with the manufacturer. Purchaser may also visit the manufacturers works to inspect design, manufacturing and test facilities.

6.4. The design review will commence after placement of award with the successful bidder and shall be finalized before commencement of manufacturing activity. These design reviews shall be carried out in detail to the specific design with reference of the reactor under the scope of this specification. It shall be conducted generally following the "Guidelines for conducting design reviews for Transformer 100 MVA and 123 kV and above" prepared by CIGRE SC 12 Working Group 12.22.

6.5. The manufacturer shall provide all necessary information and calculations to demonstrate that the reactor meets the requirements for mechanical strength and durability due to inrush current. The latest recommendations of IEC and Cigre SC 12 shall be applied for short circuit withstand evaluation.

6.6. The manufacturer will be required to demonstrate the use of adequate safety margins for thermal, mechanical, dielectric and vibration etc. in design to take into account the uncertainties of his design and manufacturing processes. The scope of such design review shall include but not limited to the requirement as mentioned at **Annexure – D**.

7. Construction Details

The construction details and features of each Shunt Reactor shall be in accordance with the requirement stated hereunder. The components and fitting associated with Reactors are subject to Purchaser's approval.

7.1. **Tank**

7.1.1. Tank shall be of welded/bolted construction and fabricated from tested quality low carbon steel of adequate thickness. Unless otherwise approved, metal plate, bar and sections for fabrication shall comply with BS-4360 / IS 2062. Material Samples, technical literature, drawings, test reports and list of the names of the principal users with experience gained shall be supplied on request.

7.1.2. All seams and those joints not required to be opened at site, shall be factory welded, and wherever possible they shall be double welded. Welding shall conform to BS-5135/IS 9595. After fabrication of tank and before painting, dye penetration test shall be carried out on welded parts of jacking bosses, lifting lugs and all load bearing members. The requirement of post weld heat treatment of tank/stress relieving shall be based on recommendation of BS-5500 table 4.4.3.1/IS 10801.

7.1.3. Tank stiffeners shall be provided for general rigidity and these shall be designed to prevent retention of water.

7.1.4. The tank shall be of proven design either bell type with bolted /welded joint or conventional type with welded / bolted top cover. Bell type tank shall be provided with joint at about 500 mm above the bottom of the tank. The welded joint shall be provided with flanges suitable for repeated welding. The joint shall be provided with a suitable gasket to prevent weld spatter inside the tank. Proper tank shielding shall be done to prevent excessive temperature rise at the joint.

7.1.5. Tank shall be provided with:

a. Lifting lugs: Four symmetrically placed lifting lugs shall be provided so that it will be possible to lift the complete Reactor when filled with oil without structural damage to any part of the Reactor. The factor of safety at any one point shall not be less than 2.

b. A minimum of four jacking pads in accessible position to enable the Reactor complete with oil to be raised or lowered using hydraulic jacks. Each jacking pad shall be designed to support with an adequate factor of safety at least half of the total mass of the Reactor filled with oil allowing in addition for maximum possible misalignment of the jacking force to the centre of the working surface.

c. Suitable haulage holes shall be provided.

d. Provision of 04 nos. of Gate valves for UHF sensors for PD Measurements at various locations. Location of valves shall be finalized during design review.

e. Suitable provisions of pockets for OTI, WTI & RTDs including two spare pockets.

7.1.6. The tank shall be designed in such a way that it can be mounted on the plinth directly.

7.1.7. The base of each tank shall be so designed that it shall be possible to move the complete Reactor unit by skidding in any direction without damage when using plates or rails.

7.2. **Tank Cover**

7.2.1. The tank cover shall be designed to prevent retention of water and shall not distort when lifted. The internal surface of the top cover shall be shaped to ensure efficient collection and direction of free gas to the buchholz relay.

7.2.2. At least two adequately sized inspection openings one at each end of the tank, shall be provided for easy access to bushings and earth connections. The inspection covers shall not weigh more than 25 kg. Handles shall be provided on the inspection cover to facilitate lifting.

7.2.3. The tank cover shall be provided with pockets for oil and winding temperature indicators. The location of pockets shall be in the position where oil reaches maximum temperature. Further, it shall be possible to remove bulbs of OTI/WTI/RTD without lowering the oil in the tank. The thermometer shall be fitted with a captive screw to prevent the ingress of water.

7.2.4. Bushing turrets, covers of inspection openings, thermometer pockets etc. shall be designed to prevent ingress of water into or leakage of oil from the tank.

7.2.5. **Currents flowing in tank cover and bushing turrets** - To allow for the effect of possible induced and capacitive surge current, the tank cover and bushing turret shall be fixed to the Reactor in such a way that good electrical contact is maintained around the perimeter of the tank and turrets.

7.2.6. The Reactor shall be provided with a 100 mm nominal diameter butterfly valve and bolted blanking plate, gasket and shall be fitted at the highest point of the Reactor for maintaining vacuum in the tank.

7.2.7. **Gas venting** - The reactor cover, and generally the internal spaces of the reactor and all pipe connections shall be designed so as to provide efficient venting of any gas in any part of the reactor to the Buchholz relay. The space created under inspection /manhole covers shall be filled with suitable material to avoid inadvertent gas pockets. The Covers shall be vented at least at both longitudinal ends. The design for gas venting shall take into accounts the slopes of the plinth (if any) on which the Reactor is being mounted.

7.3. Gasket for tank & cover

All bolted connections shall be fitted with weather proof, hot oil resistant, resilient gasket in between for complete oil tightness. If gasket is compressible, metallic stops/other suitable means shall be provided to prevent over-compression. All gasketed joints shall be designed, manufactured and assembled to ensure long-term leak and maintenance free operation. All gasketed joints unless otherwise approved shall be of the O-ring and groove type. Groove provided to accommodate round nitrile rubber cord for rectangular openings shall be milled. The Gaskets in contact with oil shall be Nitrile rubber or any better approved quality.

The properties of all the above gaskets / O-Rings shall comply with the requirements of IS-11149. Gaskets and O-rings shall be replaced every time whenever the joints are opened.

7.4. **Roller Assembly**

The Reactor shall be placed directly on concrete plinth foundation. To facilitate the movement of reactor to its foundation over rail track, bi-directional flanged rollers shall be provided. It shall be suitable for fixing to the under carriage of Reactor. The rail track gauge shall be 1676 mm.

Scope shall include supply of complete two sets of rollers assembly for movement of reactors over rail track for each substation in case scope covers more than one reactor per sub-station under the package. Otherwise, one set per substation shall be supplied.

7.5. **Foundation and Anti Earthquake Clamping Device**

To prevent Reactor movement during earthquake, suitable clamping devices shall be provided for fixing the Reactor to the foundation.

7.6. **Conservator**

7.6.1. Conservator shall have air cell type constant oil pressure system to prevent oxidation and contamination of oil due to contact with moisture. Conservator shall be fitted with magnetic oil level gauge with potential free high and low oil level alarm contacts and prismatic oil level gauge.

7.6.2. Conservator tank shall have adequate capacity with highest and lowest visible-levels to meet the requirements of expansion of total cold oil volume in the reactor and cooling equipment from minimum ambient temperature to top oil temperature of 110 deg C. The capacity of the conservator tank shall be such that the reactor shall be able to carry the specified overload without overflowing of oil.

7.6.3. The conservator shall be fitted with lifting lugs in such a position so that it can be removed for cleaning purposes. Suitable provision shall be kept to replace air cell and cleaning of the conservator as applicable.

7.6.4. Conservator shall be positioned so as not to obstruct any electrical connection to Reactor.

7.6.5. The connection of air cell to the top of the conservator is by air proof seal preventing entrance of air into the conservator. The main conservator tank shall be stencilled on its underside with the words **"Caution: Air cell fitted".** Lettering of at least 150 mm size shall be used in such a way to ensure clear legibility from ground level when the Reactor is fully installed. To prevent oil filling into the air cell, the oil filling aperture shall be clearly marked. The Reactor rating and diagram plate shall bear a warning statement that the **"Conservator is fitted with an air cell".**

7.6.6. Contact of the oil with atmosphere is prohibited by using a flexible air cell of nitrile rubber reinforced with nylon cloth. The temperature of oil in the conservator is likely to raise up to 110^{O}C during operation. As such air cell used shall be suitable for operating continuously at this temperature.

7.6.7. The reactor manual shall give full and clear instructions on the operation, maintenance, testing and replacement of the air cell. It shall also indicate shelf life, life expectancy in operation, and the recommended replacement intervals.

7.6.8. The conservator tank and piping shall be designed for complete vacuum / filling of the main tank and conservator tank. Provision must be made for equalizing the pressure in the conservator tank and the air cell during vacuum / filling operations to prevent rupturing of the air cell.

7.6.9. The contractor shall furnish the leakage rates of the rubber bag/ air cell for oxygen and moisture. It is preferred that the leakage rate for oxygen from the air cell into the oil will be low enough that the oil will not become saturated with oxygen before 10 years. Air cells with well proven long life characteristics shall be preferred.

7.7. Piping works for conservator

7.7.1. Pipe work connections shall be of adequate size for their duty and possibly short and direct. Only radiused elbows shall be used.

7.7.2. The feed pipe to the Reactor tank shall enter the reactor cover plate at its highest point and shall be straight for a distance not less than five times its internal diameter on the reactor side of the Buchholz relay, and straight for not less than three times that diameter on the conservator side of the relay. This pipe shall rise towards the oil conservator, through the Buchholz relay, at an angle of not less than 5 degrees. The feed pipe diameter for the main conservator shall be not less than 80 mm for reactor. Gas-venting pipes shall be connected to the final rising pipe between the reactor and Buchholz relay as near as possible in axial direction and preferably not less than five times pipe diameters from the Buchholz relay.

7.7.3. A double flange valve of preferably 50 mm size shall be provided to fully drain the oil from the main tank conservator.

7.7.4. Pipe work shall neither obstruct the removal of the opening of inspection or manhole covers.

7.8. Maintenance-free Dehydrating Breather

Conservator shall be fitted with a maintenance-free dehydrating breather. Connection shall be made to a point in the oil conservator not less than 50 mm above the maximum working oil level by means of a pipe with a minimum diameter of 25 mm. Breathers having a mass less than 10 kg may be supported by the connecting pipe, whereas units of 10 kg and above shall be supported independent of the connecting pipe. Connecting pipes shall be securely cleated to the reactor, or other structure supplied by the contractor, in such a manner so as to eliminate undesirable vibration and noise. In the case where a breather of less than 10 kg is supported by the pipe, there shall be a cleat directly above the breather flange. It shall be so designed that:

a) Incoming air is directed toward the desiccant (silica gel) and dried.
b) The desiccant is regenerated/dehumidified by an installed heating element that

shall be sensor-controlled and self-regulating.

c) Silicagel is isolated from atmosphere by an oil seal.

c) Moisture absorption indicated by a change in color of the crystals.

d) Breather is mounted approximately 1200 mm above rail top level.

e) To minimize the ingress of moisture three breathers (of identical size) shall be connected in series for main tank conservator. Contractor shall provide flexible connection pipes to be used during replacement of any breather.

7.9. **Pressure Relief Device**

Adequate number of pressure relief devices (at least 2 numbers) shall be provided at suitable locations preferably close to bushing turret/ cover. These shall have opening diameter of at least 100 mm for rapid release of any pressure that may be generated in the tank and which may result in damage to equipment. The device shall maintain its oil tightness under static oil pressure equal to the static operating head of oil plus 20 kPa. The device shall operate and attain its full opening in not more than 2.5 ms when subject to an internal pressure impulse equal to static operating head of oil plus 50 kPa. It shall be capable of withstanding full internal vacuum at mean sea level. It shall be mounted directly on the tank. One set of potential free contacts (**with plug & socket type arrangement suitable for 2.5sq.mm control cable)** per device shall be provided for tripping. Following routine tests shall be conducted on PRD:

a) Air pressure test
b) Liquid pressure test
c) Leakage test
d) Contact operation test
e) Dielectric test on contact terminals

7.10. **Sudden Pressure Relay**

Adequate number of Sudden Pressure relay with alarm/trip contacts **(Plug & socket type arrangement suitable for 2.5sq.mm control cable)** shall be provided on tank of Reactor. Operating features, size and quantity shall be reviewed during design review. Pressurised water ingress test for Terminal Box (routine tests) shall be conducted on Sudden Pressure Relay**.**

7.11. **Buchholz Relay**

Two numbers double float, reed type Buchholz relay shall be provided in series of the connecting pipe between the oil conservator and the Reactor tank with minimum distance of five times pipe diameters between them. Any gas evolved in the Reactor shall be collected in this relay. The relay shall be provided with a test cock suitable for a flexible pipe connection for checking its operation and taking gas sample. A copper tube shall be connected from the gas collector to a valve located about 1200 mm above ground level to facilitate sampling while the Reactor in service. Each device shall be provided with two potential free contacts **(Plug & socket type arrangement suitable for 2.5sq.mm control cable),** one for alarm / trip on gas accumulation and the other for tripping on sudden rise of pressure.

The Buchholz relay shall not operate during starting/ stopping of the Reactor oil circulation under any oil temperature conditions. The pipe or relay aperture baffles shall not be used to decrease the sensitivity of the relay. The relay shall not mal-operate for through fault conditions or be influenced by the magnetic fields around the Reactor during the external fault conditions. Pressurized water ingress test for Terminal Box (routine tests) shall be conducted on Buchholz relay.

7.12. **Oil Temperature Indicator (OTI)**

All Reactors shall be provided with a dial type thermometer of 150 mm diameter for top oil temperature indication. It shall have adjustable, potential free alarm and trip contacts **(Plug & socket type arrangement suitable for 2.5sq.mm control cable**) besides that required for control of cooling equipment if any. A temperature sensing element suitably located in a pocket on top oil shall be provided. This shall be connected to the OTI by means of capillary tubing. Temperature indicator dials shall have linear gradations to clearly read at least every 2 deg C. Accuracy of OTI shall be 3.0 deg C or better or better for a temperature of 100 deg C.

The setting of alarm and tripping contacts shall be adjustable at site after approval from the Employer.

In addition to the above, the following accessories shall be provided for remote indication of oil temperature:

a) Temperature transducer with Pt100 sensor

RTD shall be provided with Pt100 temperature sensor having nominal resistance of 100 ohms at zero degree centigrade. The Pt100 temperature sensor shall have three wire ungrounded system. The calibration shall be as per IEC 60751-2 or equivalent. The Pt100 sensor may be placed in the pocket containing temperature sensing element. RTD shall provide dual output 4-20mA for remote OTI and SCADA system individually. The transducer shall be installed in the Individual Marshalling Box. Any special cable required for shielding purpose, for connection between Pt100 temperature sensor and transducer, shall be in the scope of Contractor.

b) Remote oil temperature indicator (ROTI)

It shall be suitable for flush mounting on Employer's control panel and shall operate on 4-20mA input available from the above transducer. Any special cable required for shielding purpose, for connection among Individual Marshalling Box, Common Marshalling Box and remote OTI control circuit, shall be in the scope of Contractor.

7.13. **Winding Temperature Indicator (WTI)**

All Reactors shall be provided with a device for measuring the hot spot temperature of winding with dial type thermometer of 150 mm diameter for winding temperature indication and shall have adjustable potential free alarm and trip contacts **(Plug & socket type arrangement suitable for 2.5sq.mm control cable**) besides that required for control of cooling equipment if any. WTI shall have Temperature sensing element, Image coil and Auxiliary CTs, if required to match the image coil, shall be mounted in the cooler control cabinet. Temperature indicator dials shall have linear gradations to clearly read at least every 2 deg C. Accuracy of WTI shall be 3.0 deg C or better for a temperature of 100 deg C.

The setting of alarm and tripping contacts shall be adjustable at site after approval from the Employer.

In addition to the above, the following accessories shall be provided for remote indication of oil temperature:

a) **Temperature transducer with Pt100 sensor for each winding**

RTD shall be provided with Pt100 temperature sensor having nominal resistance of 100 ohms at zero degree centigrade. The Pt100 temperature sensor shall have three wire ungrounded system. The calibration shall be as per IEC 60751-2 or equivalent. The Pt100 sensor may be placed in the pocket containing temperature sensing element. RTD shall include image coil, Auxiliary CTs, if required to match the image coil, for WTI system and shall provide dual output 4-20mA for remote WTI and SCADA system individually. The transducer, Auxiliary CT shall be installed in the Individual Marshalling Box. Any special cable required for shielding purpose, for connection between Pt100 temperature sensor and transducer, shall be in the scope of Contractor.

c) **Remote winding temperature indicator (RWTI)**

It shall be suitable for flush mounting on Employer's control panel and shall operate on 4-20mA input available from the above transducer. Any special cable required for shielding purpose, for connection among Individual Marshalling Box, Common Marshalling Box and remote WTI control circuit, shall be in the scope of Contractor.

Only one RWTI with suitable selector switches or separate individual RWTI shall be provided for display of temperature of winding.

7.14. Optical sensors & Measuring unit

8 numbers optical temperature sensors shall be fitted on each Reactor. The optical sensors measuring system shall be of direct measurement non calibrating type. All the sensors shall be brought out to separate optical sensor box mounted on Reactor tank to facilitate measurement of temperature during service life on each unit.

In order to facilitate measurement of temperature from the optical sensors, temperature measuring unit/system having at least 8 channels shall be mounted in above optical sensor box (stainless steel) for each Reactor unit**.** The measuring unit shall be capable to retain temperature data for at least 30 days with facility to download these data.

Temperature measuring unit/system housed in above box shall be suitable for satisfactory operation with ambient conditions and IEC 61850 compliant to interface with Employer's SCADA system.

Location of optical temperature sensors inside the Reactor shall be decided during design review.

7.15. **Earthing Terminals**

7.15.1. Two (2) earthing pads (each complete with two (2) nos. holes with suitable bolts, plain and spring washers) suitable for connection to copper flat conductor cable or stranded copper wire of minimum size (cross sectional area) 160sq. mm shall be provided each at position close to earth of the two (2) diagonally opposite bottom corners of the tank.

7.15.2. Two earthing terminals suitable for connection to copper flat conductor cable or stranded copper wire of minimum size (cross sectional area) 160sq. mm shall also be provided on each individual/common marshalling box and any other equipment mounted separately. For the tank-mounted equipment like online drying/ Online DGA/etc double earthing shall be provided through the tank for which provision shall be made on the tank and connected through two flexible insulated copper link.

7.15.3. To allow for the effect of possible induced and capacitive surge current, good electrical connection is maintained between the tank and turrets. Equi-potential flexible copper link of suitable size at least 4 Nos. for Tank mounted turret with tank and tank with cover and or Bell shall be provided. For other components like - pipes, conservator support etc connected to tank shall also be provided with equipotential flexible copper link.

7.16. **Core**

7.16.1. The core shall be constructed from high grade, non-ageing, cold rolled, grain oriented silicon steel laminations (M4 or better grade).

7.16.2. The leg magnetic packets (cheeses) shall be made from state of the art low loss electrical steel. The "Cheeses" shall be designed to minimize losses and equalize the distribution of flux in the legs.

7.16.3. The "cheeses" shall be bonded using high temperature epoxy resins to assure that they will remain bonded in service at the maximum temperatures that will occur in the magnetic circuit and for the full expected life. Vacuum impregnation is preferred. The contractor shall present data on the characteristics of the packets at the time of design review.

7.16.4. Material with high temperature withstand capability such as ceramic/ slate spacers shall be used to separate the packets. High temperature, mechanically stable material shall be used between the end packets and the top and bottom yokes. Special care shall be taken not to impede the cooling in these areas.

7.16.5. Means shall be provided to distribute the flux from the "cheeses" and the windings to the top and bottom yokes to prevent concentrations of flux with resulting high temperatures in the yokes.

7.16.6. The yokes shall be designed such that high temperatures resulting from unequal distribution of the flux in the yokes will not occur.

7.16.7. The spaces between "cheeses" will be designed so that high temperatures will not result due to fringing of flux at the oil gaps between them. The designer shall calculate the temperatures resulting from fringing.

7.16.8. The design of the magnetic circuit shall be such as to avoid static discharges, development of short circuit paths within itself or to the earthed clamping structure and production of flux component at right angles to the plane of laminations which may cause local heating.

7.17. **Internal Structure Design**

7.17.1. The structural design shall be made so that pressure will be maintained to prevent loosening resulting from thermal expansion and contraction during all loading cycles.

7.17.2. The design shall be made in such a way that excessive vibration does not occur in the windings, structural supports of the windings and magnetic circuit and this will be subjected to design review.

7.17.3. The structure shall be designed to withstand the clamping and magnetic forces. The calculated magnetic forces will be furnished at the time of design review.

7.17.4. Core and winding shall be capable of withstanding the shock during transport, installation and service. Adequate provision shall be made to prevent movement of core and winding relative to tank during these conditions.

7.18. **Earthing of core and clamping structure**

7.18.1. If grounding of the core cheeses are required a separate strap shall be brought to a terminal located in a waterproof enclosure on the tank. Separate ground leads will be routed from the top and bottom yokes to separate terminals in the enclosure.

7.18.2. The core shall be earthed to the core clamping structure at one point only, through a removable external link suitably located and protected to facilitate testing after installation of the reactor. The removable links shall have adequate section to carry ground fault current. Separate identification name plate/labels shall be provided for the 'Core' and 'Core clamp' on the tank cover.

7.18.3. Unless otherwise approved, no core earthing connection shall be of minimum size of 80 sq.mm copper with exception of the connections inserted between laminations which may be reduced to a cross-sectional area of 20 sq. mm tinned copper where they are clamped between the laminations.

7.18.4. Where the core laminations are divided into sections by insulating barriers or cooling ducts parallel to the plane of the laminations, tinned copper bridging strips shall be inserted to maintain electrical continuity between sections.

7.18.5. A drawing showing the details of the earthing design and connection shall be furnished during detailed engineering.

7.19. **Windings**

7.19.1. The Contractor shall ensure that windings of all Reactors are made in dust proof and conditioned atmosphere.

7.19.2. The conductors shall be of electrolytic grade copper free from scales and burrs.

7.19.3. The insulation of Reactor windings and connections shall be free from insulating compounds which are liable to soften, ooze out, shrink or collapse and shall be non-catalytic and chemically inactive in Reactor oil during service.

7.19.4. Coil assembly and insulating spacers shall be so arranged as to ensure free circulation of oil and to reduce the hot spot of the winding.

7.19.5. The coils would be made up, shaped and braced to provide for expansion and contraction due to temperature changes.

7.19.6. The conductor shall be transposed at sufficient intervals in order to minimize eddy currents and to equalize the distribution of currents and temperature along the winding.

7.19.7. The windings shall be designed to withstand the dielectric tests specified. The type of winding used shall be of time tested. An analysis shall be made of the transient voltage distribution in the windings, and the clearances used to withstand the various voltages. Margins shall be used in recognition of manufacturing tolerances and the fact that the system will not always be in the new factory condition.

7.19.8. The barrier insulation including spacers shall be made from high- density pre-compressed pressboard (1.1 gm/cc minimum for load bearing and 1 to 1.3 gm/cc minimum for non-load bearing) to minimize dimensional changes.

7.19.9. All spacers shall have rounded edges. Radially stepped spacers between winding disks will not be accepted.

7.19.10. The conductor insulation shall be made from high-density (at least 0.75 gm/cc) paper having high mechanical strength. The characteristics for the paper will be reviewed at the time of design review.

7.19.11. An electrostatic shield, made from material that will withstand the mechanical forces, will be used to shield the high voltage windings from the magnetic circuit unless otherwise approved.

7.19.12. **Bracing of windings**

All winding insulation shall be processed to ensure that there will be no detrimental shrinkage after assembly. All windings shall be pre-sized before being clamped. Windings shall be provided with clamping arrangements which will distribute the clamping forces evenly over the ends of the winding.

The bracing of the windings and connections shall be such that these parts shall safely withstand the cumulative effects of stresses which may occur during handling, transportation, installation and service including line-to–line and line-to–ground faults.

Full details of the winding clamping arrangements, and their adjustment in or out of the tank together with relevant drawings and values, shall be submitted during design review.

7.20. **Current carrying connections**

The mating faces of bolted connections shall be appropriately finished and prepared for achieving good long lasting, electrically stable and effective contacts. All lugs for crimping shall be of the correct size for the conductors. Connections shall be carefully designed to limit hot spots due to circulating eddy currents.

7.21. **Winding terminations into bushings**

7.21.1. Winding termination interfaces with bushings shall be designed to allow for repeatable and safe connection under site conditions to ensure the integrity of the Reactor in service.

7.21.2. The winding–end termination, insulation system and transport fixings shall be so designed that the integrity of the insulation system generally remains intact during repeated work in this area.

7.21.3. Allowances shall be made on the winding ends for accommodating tolerances on the axial dimensions of the set of bushings and also for the fact that bushings may have to be rotated.

7.21.4. In particular, rotation or straining of insulated connections shall be avoided during the fastening of conductor pads (or other methods) on the winding ends onto the termination surfaces of the bushing.

7.21.5. Suitable inspection and access facilities into the tank in the bushing oil-end area shall be provided to minimize the possibility of creating faults during the installation of bushings.

8. Painting system and procedures

The typical painting details for reactor main tank, pipes, conservator tank, radiator, control cabinet/ marshalling box / oil storage tank etc. shall be as given in **Annexure – E**. The proposed paint system shall generally be similar or better than this. The quality of paint should be such that its colour does not fade during drying process and shall be able to withstand temperature up to 120 deg C. The detailed painting procedure shall be finalized during award of the contract.

9. Unused inhibited Insulating Oil

The insulating oil shall be virgin high grade inhibited, conforming to IEC-60296 & all parameters specified at **Annexure – F**, while tested at supplier's premises. The contractor shall furnish test certificates from the supplier against the acceptance norms as mentioned here, prior to despatch of oil from refinery to site. Under no circumstances, poor quality oil shall be filled into the Reactor and only thereafter brought the specified parameter by circulation within the Reactor. The Unused inhibited Insulating Oil parameters including parameters of oil used at manufacturer's works, processed oil, oil after filtration and settling are attached at **Annexure – F**. The oil test results shall form part of equipment test report.

Sufficient quantity of oil necessary for maintaining required oil level in case of leakage in tank, radiators, conservator etc. till the completion of warranty period shall be supplied.

Inhibited oil used for first filling, testing and impregnation of active parts at manufacturer's works shall be of same type of oil (in line with IEC 60076-3) which shall be supplied at site and shall meet parameters as per specification.

9.1. **Particles in the oil**

The particle analysis shall be carried out in an oil sample taken after completion of the oil filtration at site. The procedure and interpretation shall be in accordance with the recommendation of CIGRE report WG-12.17 - "Effect of particles on transformer dielectric strength".

9.2. **Moisture content in the solid insulation**

Dummy insulation test block shall be inserted in the active part of Reactor at factory and same shall be used to detect the volume moisture content. Manufacturer to ensure that moisture content in the dummy insulation test block is less than 0.5% after drying process of solid insulation. Measurement shall be carried out as per IEC.

9.3. **Oil filling**

9.3.1. Procedures for site drying, oil purification, oil filling etc shall be done as per approved Quality Plan (QP).

9.3.2. The duration of the vacuum treatment shall be demonstrated as adequate by means of water / dew point measurement with a cold trap or other suitable method. The vacuum shall be measured on the top of the Reactor tank and should be less than 1mbar.

9.3.3. Oil filling under vacuum at site shall be done with reactor oil at a temperature not exceeding 65°C. Vacuum shall not be broken until the Reactor is oil filled up to the Buchholz relay.

9.3.4. The minimum safe level of oil filling (if different from the Buchholz level) to which the Reactor shall be oil filled under vacuum, shall be indicated in the manual.

9.3.5. The Ultra High Vacuum type oil treatment plant of suitable capacity (**minimum 6000** litres per hour) suitable for treatment of oil in EHV class Reactor shall be used in order to achieve properties of treated oil. The plant shall be capable of treatment of new oil (as per IEC 60296 and reconditioning of used oil (as per IS: 1866/IEC: 60422 for oil in service) at rated capacity on single pass basis as follow:

i) Removal of moisture from 100 ppm to 3 ppm (max.)
ii) Removal of dissolved gas content from 10% by Vol. to 0.1% by vol.
iii) Improvement of dielectric strength break down voltage from 20 to 70 KV
iv) Vacuum level of degassing chamber not more than 0.15 torr/0.2 mbar at rated flow and at final stage. Machine shall have minimum of two degassing chambers and these should have sufficient surface areas to achieve the final parameters.
v) Filter shall be capable of removing particle size more than 0.5 micron in the filtered oil.
vi) Processing temperature shall be automatically controlled and have an adjustable range from 40 C to 80 C.

9.3.6. **Transportation of Oil**

The insulating oil for the Reactor shall be delivered at site generally not before 90 days from the date of commissioning, with prior information to the Employer.

Insulating oil shall be delivered to the site in returnable oil drums / flexi bag / tanker. The oil drums / flexi bag / tanker shall be taken back without any extra cost to Employer within generally 45 days after utilization of oil but in any case before contract closing. However, the spare oil shall be delivered in non-returnable drums.

10. Preparation of spare unit

10.1. **Unit in service:** In case, purchaser intends to replace any of the Reactor units by spare unit through isolator switching arrangement i.e. without physically shifting of the Reactors, the spare Reactor shall be completely erected, oil filled and commissioned similar to the other Reactors.

10.2. **Unit for long term storage:** In case, due to space limitation, Isolator based switching arrangement is not possible, the faulty unit shall be replaced with spare unit by physical shifting. The spare unit shall be completely erected at the identified location/foundation in the substation, oil filled and commissioned similar to the other Reactors with all accessories (except cooler/radiator bank) for long-term storage. The contractor shall carry out all pre-commissioning tests on the spare Reactor similar to the unit kept in service. After completion of pre-commissioning tests, bushings may be dismantled and re-packed or erected condition as advised by Employer. If the conservator is mounted on cooler bank, suitable arrangement shall be made for the conservator to be mounted on tank top during long-term storage of Reactor. Radiators shall be kept in original packing and shall be stored as per the direction of site Engineer in charge or in erected condition wherever storage space not available.

All other accessories/fittings etc. shall be suitably packed in reusable boxes in line with standard drawings/documents. Instructions for dismantling, installation and safe storage shall be provided with every packing box. Arrangement shall be made to minimize moisture ingress inside the boxes. All pipes and radiators shall be provided with blanking plates during storage to prevent entry of foreign material/ water.

In addition to the blanking plates & covers provided during transportation, one complete set of all metal blanking plates and covers, which are specifically required during transport and storage at site shall be considered as integral part of each Reactor and handed over to the site packed in a separate box. Bill of quantity and relevant drawings of these items shall also be provided to enable the Purchaser to re-fabricated, if required.

In case spare Reactors needs to be commissioned similar to the unit in service, as advised by Employer, the same shall be erected, tested and commissioned as per standard procedures. However, other accessories/fittings/packing materials etc. As required for long-term storage shall be considered include in the scope of bidder.

Any special maintenance procedure required during long-term storage shall be clearly brought out in the instruction manual.

11. Bushings

11.1. Bushings shall be robust and designed for adequate cantilever strength to meet the requirement of seismic condition, substation layout and movement along with the spare Reactor with bushing erected and provided with proper support from one foundation to another foundation within the substation area. The electrical and mechanical characteristics of bushings shall be in accordance with IEC: 60137/DIN 42530. All details of the bushing shall be submitted for approval and design review.

11.2. Bushing for voltage of 52 kV and above shall be RIP bushing with composite insulator. 36 kV bushing shall be solid porcelain or oil communicating type.

11.3. RIP type bushing shall be provided with tap for capacitance and tan delta test. Test taps relying on pressure contacts against the outer earth layer of the bushing is not acceptable.

11.4. Where current transformers are specified, the bushings shall be removable without disturbing the current transformers.

11.5. Bushings of identical rating shall be interchangeable to optimize the requirement of spares.

11.6. Porcelain used in bushing manufacture shall be homogenous, free from lamination, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.

11.7. Polymer / composite insulator shall be seamless sheath of a silicone rubber compound. The housing & weather sheds should have silicon content of minimum 30% by weight. It should protect the bushing against environmental influences, external pollution and humidity. The interface between the housing and the core must be uniform and without voids. The strength of the bond shall be greater than the tearing strength of the polymer. The manufacturer shall follow non-destructive technique (N.D.T.) to check the quality of jointing of the housing interface with the core. The technique being followed with detailed procedure and sampling shall be finalized during finalization of MQP.

The weather sheds of the insulators shall be of alternate shed profile as per IEC 60815-3. The weather sheds shall be vulcanized to the sheath (extrusion process) or moulded as part of the sheath (injection moulding process) and free from imperfections. The vulcanization for extrusion process shall be at high temperature and for injection moulding shall be at high temperature & high pressure. Any seams / burrs protruding axially along the insulator, resulting from the injection moulding process shall be removed completely without causing any damage to the housing. The track resistance of housing and shed material shall be class 1A4.5 according to IEC60587**.** The strength of the weather shed to sheath interface shall be greater than the tearing strength of the polymer. The composite insulator shall be capable of high pressure washing.

End fittings shall be free from cracks, seams, shrinks, air holes and rough edges. End fittings should be effectively, sealed to prevent moisture ingress, effectiveness of sealing system must be supported by test documents. All surfaces of the metal parts shall be perfectly smooth with the projecting points or irregularities which may cause corona. All load bearing surfaces shall be smooth and uniform so as to distribute the loading stresses uniformly.

The hollow silicone composite insulators shall comply with the requirements of the IEC publications IEC 61462 and the relevant parts of IEC 62217. The design of the composite insulators shall be tested and verified according to IEC 61462 (Type & Routine test)

11.8. Clamps and fittings shall be of hot dip galvanised/stainless steel.

11.9. Bushing turrets shall be provided with vent pipes, to route any gas collection through the Buchholz relay.

11.10. No arcing horns shall be provided on the bushings.

11.11. Spare Bushing shall be specially packed to avoid any damage during transit and suitable for long storage, with non-returnable packing wooden boxes with hinged type cover. Without any gap between wooden planks. Packing Box opening cover with nails/screws type packing arrangement shall not be acceptable. In case of RIP bushing with polymer housing, Bushing oil end portion shall be fitted with metal housing with positive dry air pressure and a suitable pressure monitoring device shall be fitted on the metal housing during storage to avoid direct contact with moisture with epoxy. Alternatively, oil filled metal housing with suitable arrangement for taking care oil expansion due to temperature variations shall also be acceptable. Manufacturer shall submit drawing/ documents of packing for approval during detail engineering. Detail method for storage of bushing including accessories shall be brought out in the instruction manual.

11.12. The terminal marking and their physical position shall be as per IEC: 60076.

12. Neutral Formation and Earthing Arrangement

The neutral formation of reactor windings shall be made inside the tank and shall be brought out of Reactor tank through Neutral bushing. CT's for Shunt Reactor Differential Protection shall be provided before neutral formation and CT terminals bought out of the tank suitably. All the cabling of CTs is in the scope of the supplier to achieve all the protection scheme (Differential, REF and back-up over-current).

The neutral of Shunt Reactor shall be grounded directly. The neutral terminal of Reactors shall be brought to the ground level by a brass/tinned copper grounding bar, supported from the tank by using porcelain insulators. The end of the brass/tinned copper bar shall be brought to the bottom of the tank, at a convenient point, for making bolted connection to two (2) copper flat conductor cable or stranded copper wire of minimum size (cross sectional area) 160sq. mm connected to Substation grounding mat.

14. Cooling Equipment

14.1. The reactor shall be designed for Oil Natural Air Natural Cooling (ONAN)

14.2. The radiator bank of the shunt reactor shall be either tank mounted or separately mounted based on manufacturer's standard practice.

14.3. Design of cooling system shall satisfy the performance requirements. The radiator shall be of sheet steel in accordance with international standard and minimum thickness 1 mm. Each radiator bank shall be provided with the following accessories:

(a) Top and bottom shut off valve
(b) Drain Valve and sampling valve
(c) Air release plug
(d) Two grounding terminals for termination of two (2) Nos. copper flat conductor cable or stranded copper wire of minimum size (cross sectional area) 160sq. mm.
(e) Thermometer pockets with captive screw caps at cooler inlet and outlet.
(f) Lifting lugs

14.4. Each radiator bank shall be detachable and shall be provided with flanged inlet and outlet branches. Expansion joint shall be provided on top and bottom cooler pipe connection for separately mounted radiator bank.

14.5. The cooler pipes, support structure including radiators and its accessories shall be hot dip galvanised or corrosion resistant paint should be applied to external surface of it.

15. Cabling

All interconnecting control and power cables between various parts of Reactors like turret CT, MBs, Buchholz, PRD etc. shall be routed through covered cable tray or GI conduit and shall be properly dressed. All cables shall be armoured type. Un-armoured cables (if provided) in any circuitry, shall be through GI conduit and no part shall be exposed. Cable terminations shall be through stud type TB and ring type lugs. Contractor shall provide type tested cables from approved sources. No type testing for cables is envisaged. Further, any special cables (if required) shall also be considered included in the scope.

16. Valves

16.1. All valves upto and including 100 mm shall be of gun metal or of cast steel/cast iron. Larger valves may be of gun metal or may have cast iron bodies with gun metal fittings. They shall be of full way type with internal screw and shall open when turned counter clock wise when facing the hand wheel.

16.2. Suitable means shall be provided for locking the valves in the open and close positions. Provision is not required for locking individual radiator valves.

16.3. Each valve shall be provided with the indicator to show clearly the position of the valve.

16.4. All valves flanges shall have machined faces.

16.5. All valves in oil line shall be suitable for continuous operation with Reactor oil at 115 deg C.

16.6. The oil sampling point for main tank shall have two identical valves to be put in series. Oil sampling valve shall have provision to fix rubber hose of 10 mm size to facilitate oil sampling.

16.7. Valves or other suitable means shall be provided to fix the on line DGA monitoring systems to facilitate continuous monitoring. The location & size of the same shall be finalised during detail design review.

16.8. **Flow sensitive conservator Isolation valve**

a) In order to restrict the supply of oil in case of a fire in Reactor, flow sensitive valve shall be provided to isolate the conservator oil from the main tank.

b) A valve which shall be flow sensitive and shut off when the flow in the pipe is more than the flow expected in the permissible normal operating conditions. This valve shall be located in the piping between the conservator and the buchholz relay and shall not affect the flow of oil from and to the conservator in normal conditions.

c) When the flow from conservator to main tank is more than the normal operating conditions, the valve shall shut off by itself and will have to be reset manually. It shall be provided with valve open/close position indicator along with alarm contact indication in control room during closing operation of valve. This valve shall be provided with locking arrangement for normal position and oil filling / filtration position. A suitable platform / ladder shall be provided to approach the valve for manual reset.

16.9. All valves shall be painted with a shade (preferably red or yellow distinct and different from of main tank surface and as per the painting system and procedure specified.

16.10. All hardware used shall be hot dip galvanised / stainless steel.

17. Individual Marshalling Box and Common Marshalling Box

17.1. Each single phase reactor unit shall be provided with Individual Marshalling Box and Common Marshalling Box (for a bank of three single phase unit) whereas each three phase shunt reactor shall be provided with Individual Marshalling Box.

17.2. All out door control cabinets shall be made of stainless steel sheet of at least 1.6 mm thick. The degree of protection shall be at least IP: 55 for outdoor and IP: 43 for indoor in accordance with IS: 13947/IEC: 60947.

17.3. All doors, removable covers and plates shall be gasketed all around with suitably profiled. All gasketed surfaces shall be smooth straight and reinforced if necessary to minimize distortion to make a tight seal. For Control cubicle / Marshalling Boxes etc. which are outdoor type, all the sealing gaskets shall be of EPDM rubber or any better approved quality, whereas for all indoor control cabinets, the sealing gaskets shall be of neoprene rubber or any better approved quality. The gaskets shall be tested in accordance with approved quality plan, IS: 1149 and IS: 3400. Ventilating Louvers, if provided, shall have screen and filters. The screen shall be fine wire mesh of brass. All the separately mounted cabinets and panels shall be free standing floor mounted type and have domed or sloping roof. All the control cabinets shall be provided with suitable lifting arrangement. Individual Marshalling Box shall be tank mounted only.

17.4. All the contacts of various protective devices mounted on the reactor and all the secondary terminals of the bushing CTs shall also be wired upto the terminal board in the Individual Marshalling box. All the CT secondary terminals in the Individual Marshalling box shall have provision for shorting to avoid CT open circuit while it is not in use. All the necessary terminations for remote connection to Purchaser's panel shall be wired upto the Common Marshalling box.

17.5. A space heater and cubicle lighting with ON-OFF switch shall be provided in each panel.

17.6. Control and power supplies are to be given after suitable selection at Common Marshalling Box. Necessary isolating switches and protective devices shall be provided at suitable points as per Purchaser's approved scheme.

17.7. The temperature indicators shall be so mounted that the dials are about 1200 mm from ground level. Glazed door of suitable size shall be provided for convenience of reading.

17.8. All the control circuit connections from individual marshalling box and of three single phase units of a bank including spare reactor unit to Purchasers Control panels shall be routed through common marshalling box. Common marshalling box shall be floor mounted and of size not less than 1600mm (front) X 650mm (depth) X 1800mm (height).

17.9. Connection arrangement for spare unit shall be in such a way that spare unit of reactor can be connected in place of faulty unit without physically shifting, and all the control, protection, indication signals of spare unit shall also be brought in common marshalling box of all the banks. Necessary arrangement in schematic of Common marshalling box is required to facilitate changeover of all the signals of faulty units to spare unit of reactor, to ensure flow of control, protection and indication signals between Purchasers Control panels and individual units under operation (i.e. any designated unit for bank or spare unit, if it replace any designated unit). The control and monitoring terminations of a spare Reactor unit shall be brought to CMB. The necessary switching arrangement through male-female plug-in TB assembly shall be provided for replacing spare unit with any one of the faulty phase unit for monitoring & control from CMB.

17.10. Details of station auxiliary power supply are mentioned in Chapter - GTR. Common marshalling box shall have following arrangement:

17.10.1. Two auxiliary power supplies, 415 volt, three phase four (4) wire shall be provided by the Purchaser at common marshalling box (for Single Phase unit) or Individual Marshalling Box (for Three Phase unit).

17.10.2. Suitably rated power contractors, MCBs/MCCBs as required for entire auxiliary power supply system including distribution to individual marshalling boxes, Online Moisture & Hydrogen monitoring system, Online drying system and Fibre optic sensor Box etc., shall be provided by contractor. For each circuit separate MCBs / MCCBs shall be provided in the Common Marshalling Box.

17.10.3. In case auxiliary power supply requirement is different than station auxiliary AC supply, then all necessary converters shall be provided by the Contractor. Auxiliary power supply distribution scheme shall be submitted for approval.

17.10.4. Supply and laying of Power, Control and special cables from common marshalling box to individual units (including spare unit) is in the scope of the contractor.

17.11. All loads shall be fed by one of the two feeders through an electrically interlocked automatic transfer scheme housed in the common marshalling box. Design features of the transfer scheme shall include the following:

a) Provision for the selection of one of the feeder as normal source and other as standby.
b) Upon failure of the normal source, the loads shall be automatically transferred after an adjustable time delay to standby sources.
c) Indication to be provided at marshalling box for failure of normal source and for transfer to standby source and also for failure to transfer.
d) Automatic re-transfer to normal source without any intentional time delay following re-energization of the normal source.

e) Both the transfer and the re-transfers shall be dead transfers and AC feeders shall not be paralleled at any time.

18. Current Transformer (Bushing & Outdoor Neutral Current Transformer)

18.1. Current transformers shall comply with IEC-60044-1.

18.2. It shall be possible to remove the turret mounted current transformers from the Reactor tank without removing the tank cover. Necessary precautions shall be taken to minimize eddy currents and local heat generated in the turret.

18.3. Current transformer secondary leads shall be brought out to a weatherproof terminal box near each bushing. These terminals shall be wired out to common marshalling box using separate cables for each core.

18.4. For 1-Phase Reactor, one number single phase current transformer (outdoor) for earth fault protection shall be provided for each bank of reactor and shall be located in the neutral conductor connecting common neutral point with earth.

18.5. Technical Parameters of Bushing CTs and Neutral CTs are enclosed at **Annexure – G.** The CT's used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection. Bushing Current transformer parameters indicated in this specification are tentative and liable to change within reasonable limits. The Contractor shall obtain Purchaser's approval before proceeding with the design of bushing current transformers.

18.6. Secondary resistance and magnetising current characteristics of TPS class (protection) (as per IEC) CT of same rating shall be identical. This is applicable for Neutral CT (outdoor) also and shall be reviewed during detail engineering.

19. Fittings

The following fittings shall be provided with each shunt reactor and for neutral grounding reactor (as applicable) covered under this specification.

a. Conservator for main tank with aircell, oil filling hole and cap, isolating valves, drain valve, magnetic oil level gauge with potential free high and low oil level alarm contacts and dehydrating breather.

b. Pressure relief devices with trip contact

c. Sudden pressure relief relay with trip contact

d. Buchholz relay double float, reed type with isolating valves on both sides, bleeding pipe with pet cock at the end to collect gases and alarm / trip contacts.

e. Air release plug

f. Inspection openings and covers

g. Bushing with metal parts and gaskets to suit the termination arrangement with lead if applicable

h. Winding & Oil temperature indicators for local and remote mounting

i. Cover lifting eyes, reactor lifting lugs, jacking pads, towing holes and core and winding lifting lugs

j. Protected type mercury or alcohol in glass thermometer or magnetic or micro-switch type dial type temperature indicator

k. Bottom and top filter valves with threaded male adaptors, bottom sampling valve and drain valve

l. Rating and diagram plates on reactors and auxiliary apparatus

m. Roller Assembly

n. Individual marshalling box, Common Marshalling Box, Fibre optic sensor box

o. Cooling equipment

p. Bushing current transformers, Neutral CT (if applicable)

q. Drain valves/plugs shall be provided in order that each section of pipe work can be drained independently

r. Terminal marking plates

s. Suitable neutral bus connection

t. Valves schedule plate

u. Bottom oil sampling valve and drain valves

v. Filter valves at top and bottom

w. Shut off valves on the pipe connection between radiator bank and reactor tank

x. Shut off valves on both sides of Buchholz relay at accessible height

y. Sampling gas collectors for Buchholz relay at accessible height

z. Minimum four jacking pads

aa. Lifting lugs/eyes for the cover.

bb. Suitable terminal connectors on bushings and surge arrester

cc. Ladder to climb up to the Reactor tank cover with suitable locking arrangement to prevent climbing during charged condition.

dd. Suitable Platform for safe access of Flow sensitive non-return valve and buchholz relay shall be provided, in case these are not accessible from Reactor top.

ee. Haulage lugs

ff. On line insulating oil drying system

gg. On line dissolved gases and moisture monitor (if specified in BPS)

hh. Fibre optic sensor based temperature measuring system (applicable for 400kV Reactor)

ii. Flow sensitive conservator Isolation valve

jj. Two earthing terminals each on shunt reactor tank, radiators & marshalling boxes, SA structures etc.

kk. Suitable neutral bus connection arrangement

ll. All hardware used shall be hot dip galvanised / stainless steel

mm. The fittings listed above are only indicative and any other fittings which are generally required for satisfactory operation of the reactors are deemed to be included.

nn. Managed Ethernet switch, LIU patch cords etc. shall be provided in CMB. All IEC 61850 compliant signals from various monitoring equipment/accessories shall be wired upto the Ethernet switch.

20. Online Dissolved Gas (Multi-gas) and Moisture Analyzer

Online Dissolved Gas (Multi-gas) and Moisture Analyser (if specified in BPS) along with all required accessories shall be provided with each reactor for measurement & analysis of dissolved gases and moisture in the oil. The detailed technical specification of is enclosed at **Annexure-K**.

21. On Line Dissolved Hydrogen and Moisture Monitor

Online Dissolved Hydrogen and Moisture Monitor (if specified in BPS) along with all required accessories shall be provided with each reactor for monitoring of dissolved Hydrogen and moisture in the oil. The detailed technical specification is enclosed at **Annexure-L**.

22. On-line insulating oil drying system (Cartridge type)

On-line insulating oil drying system (Cartridge type) along with all required accessories shall be provided with each Reactor. The detailed technical specification is enclosed at **Annexure-M**.

23. Nitrogen Injection Type Fire Protection System (NIFPS)

Nitrogen Injection Type Fire Protection System (NIFPS) (if specified in BPS) shall be designed to prevent explosion of transformer/reactor tank and the fire during internal faults resulting from arc. The detailed technical specification of is enclosed at **Annexure-J**.

24. Oil Sampling Bottle

Oil sampling bottles (if specified in BPS) shall be suitable for collecting oil samples from Reactors and shunt Reactors, for Dissolved Gas Analysis. Bottles shall be robust enough, so that no damage occurs during frequent transportation of samples from site to laboratory.

Oil sampling bottles shall be made of stainless steel having a capacity of 1litre. Oil Sampling bottles shall be capable of being sealed gas-tight and shall be fitted with cocks on both ends.

The design of bottle & seal shall be such that loss of hydrogen shall not exceed 5% per week.
An impermeable oil-proof, transparent plastic or rubber tube of about 5 mm diameter, and of sufficient length shall also be provided with each bottle along with suitable connectors to fit the tube on to the oil sampling valve of the equipment and the oil collecting bottles respectively.

The scope of oil sampling bottles shall be included in the bid price as per the quantity indicated in the bid price schedule.

25. Oil Syringe

If specified in BPS, the glass syringe of capacity 50ml (approx) and three way stop cock valve shall be supplied. The syringe shall be made from Heat resistant borosilicate Glass. The material and construction should be resistant to breakage from shock and sudden temperature changes, reinforced at luer lock tip Centre and barrel base.

The cylinder-Plunger fitting shall be leak proof and shall meet the requirement of IEC-60567. Plunger shall be grounded and fitted to barrel for smooth movement with no back flow. Barrel rim should be flat on both sides to prevent rolling and should be wide enough for convenient finger tip grip. The syringe shall be custom fit and uniquely numbered for matching. The syringe shall be clearly marked with graduations of 2.0 ml and 10.0 ml and shall be permanently fused for life time legibility.

26. Oil Storage Tank

26.1. Oil storage tank shall be of minimum capacity (as per BPS) along with complete accessories. The oil storage tank shall be designed and fabricated as per relevant Indian Standards e.g. IS: 803 or other internationally acceptable standards. Reactor oil storage tanks shall be towable on pneumatic tyres and rested on manual screw jacks of adequate quantity & size. The tank shall be cylindrical in shape and mounted horizontally and made of mild steel plate of adequate thickness. Diameter of the tank shall be 2.0 meter approximately. The tank shall be designed for storage of oil at a temperature of 100 C.

26.2. The maximum height of any part of the complete assembly of the storage tank shall not exceed 4.0 metres above road top.

26.3. The tank shall have adequate number of jacking pad so that it can be kept on jack while completely filled with oil. The tank shall be provided with suitable saddles so that tank can be rested on ground after removing the pneumatic tyres.

26.4. The tank shall also be fitted with manhole, outside & inside access ladder, silica gel breather assembly, inlet & outlet valve, oil sampling valve with suitable adopter, oil drainage valve, air vent etc. Pulling hook on both ends of the tank shall be provided so that the tank can be pulled from either end while completely filled with oil. The engine capacity in horse power to pull one tank completely fitted with oil shall be indicated. Oil level indicator shall be provided with calibration in terms of litre so that at any time operator can have an idea of oil in the tank. Solenoid valve (Electro-mechanically operated) with Centrifugal pump shall be provided at bottom inlet so that pump shall be utilised both ways during oil fill up and draining. Suitable arrangement shall also be provided to prevent overflow and drain form the tank.

26.5. The following accessories shall also form part of supply along with each Oil storage tank.

i) Four numbers of 50NB suitable rubber hoses for Reactor oil application up to temperature of 100 C, full vacuum and pressure up to 2.5 Kg/ cm2 with couplers and unions each not less than 10 metre long shall be provided.

ii) Two numbers of 100NB suitable for full vacuum without collapsing and kinking vacuum hoses with couplers and unions each not less than 10 metre long shall also be provided.

iii) One number of digital vacuum gauge with sensor capable of reading up to 0.001 torr, operating on 240V 50Hz AC supply shall be supplied. Couplers and unions for sensor should block oil flow in the sensor. Sensor shall be provided with at-least 8 meter cable so as to suitably place the Vacuum gauge at ground level.

26.6. The painting of oil storage tank and its control panel shall be as per technical specification.

26.7. The tank shall contain a self mounted centrifugal oil pump with inlet and outlet valves, with couplers -suitable for flexible rubber hoses and necessary switchgear for its control. There shall be no rigid connection to the pump. The pump shall be electric motor driven, and shall have a discharge of not less than 6.0 kl/hr. with a discharge head of 8.0m. The pump motor and the control cabinet shall be enclosed in a cubicle with IP-55 enclosure.

27. Hand Tools

One set of hand tools **(if specified in BPS)** of reputed make packed in a carry bag/box broadly comprising of double ended spanners (open jaws, cranked ring, tubular with Tommy bar each of sizes 9mm to 24mm, one set each), adjustable wrenches (8 &12 inch one set), gasket punches (of different sizes used - one set), pliers (flat nose, round nose & side cutting one of each type), hammer with handle (one), files with handle (two), knife with handle (one), adjustable hacksaw (one), and cold chisel (one), bushing handling and lifting tools with nylon rope/belt, chain block (2 Nos.) and D-Shackle shall be supplied per Substation for which cost shall be deemed included.

28. Test Kit

BDV Kit (if specified in BPS)as per **Annexure-H** of specification
Portable DGA Kit (if specified in BPS)as per **Annexure-H** of specification

29. Inspection and Testing

The Contractor shall carry out a comprehensive inspection and testing programme during manufacture of the equipment. The inspection envisaged by the Purchaser is given below. This is however not intended to form a comprehensive programme as it is Contractor's responsibility to draw up and carry out such a programme in the form of detailed quality plan duly approved by Purchaser for necessary implementation.

29.1. **Inspection**

29.1.1. **Tank and Conservator**

a. Certification of chemical analysis and material tests of plates
b. Check for flatness
c. Electrical interconnection of top and bottom by braided tinned copper flexible
d. Welder's qualification and weld procedure
e. Testing of electrodes for quality of base materials and coatings
f. Inspection of major weld preparation
g. Crack detection of major strength weld seams by dye penetration test
h. Measurement of film thickness of:
   i. Oil insoluble varnish
   ii. Zinc chromate paint
   iii. Finished coat
i. Check correct dimensions between wheels, demonstrate turning of wheels through 90 degree and further dimensional check.
j. Check for physical properties of materials for lifting lugs, jacking pads, etc. All load bearing welds including lifting lug welds shall be subjected to Non Destructive Testing.
k. Leakage test of the conservator
l. Certification of all test results

29.1.2. **Core**

a. Sample testing of core materials for checking specific loss, bend properties, magnetisation characteristics and thickness
b. Check on the quality of varnish if used on the stampings:

i) Measurement of thickness and hardness of varnish on stampings
ii) Solvent resistance test to check that varnish does not react in hot oil
iii) Check overall quality of varnish by sampling to ensure uniform shining colour, no bare spots, no over burnt varnish layer and no bubbles on varnished surface

c. Check on the amount of burrs
d. Bow check on stampings
e. Check for the overlapping of stampings. Corners of the sheet are to be part.
f. Visual and dimensional check during assembly stage
g. Check for inter-laminar insulation between core sectors before and after pressing
h. Visual and dimensional checks for straightness and roundness of core, thickness of limbs and suitability of clamps
i. High voltage test (2 kV for one minute) between core and Yoke clamps, Yoke clamps to tank and Core to Tank
j. Certification of all test results

29.1.3. **Insulation Material**

a. Sample check for physical properties of materials
b. Check for dielectric strength
c. Visual and dimensional checks
d. Check for the reaction of hot oil on insulating materials
e. Dimension stability test at high temperature for insulating material
f. Tracking resistance test on insulating material
g. Certification of all test results

29.1.4. **Winding**

a. Sample check on winding conductor for mechanical properties and electrical conductivity
b. Visual and dimensional checks on conductor for scratches, dent marks etc.
c. Sample check on insulating paper for pH value, bursting strength and electric strength
d. Check for the reaction of hot oil on insulating paper
e. Check for the bonding of the insulating paper with conductor
f. Check and ensure that physical condition of all materials taken for windings is satisfactory and free of dust
g. Check for absence of short circuit between parallel strands
h. Check for brazed joints wherever applicable
i. Measurement of impedance by low voltage to be carried out when core/yoke is completely restacked and all connections are ready.
j. Conductor enamel test for checking of cracks, leakage and pin holes
k. Conductor flexibility test
l. Heat shock test for enamelled wire
m. Certification of all test results

29.1.5. **Checks Before Drying Process**

a. Check condition of insulation on the conductor and between the windings.

b. Check insulation distance between high voltage connections, cables and earth and other live parts
c. Check insulating distances between low voltage connections and earth and other parts
d. Insulation of core shall be tested at 2 kV/minute between core and Yoke clamps, Yoke clamps to tank and Core to Tank
e. Check for proper cleanliness and absence of dust etc
f. Certification of all test results

29.1.6. **Checks During Drying Process**

a. Measurement and recording of temperature, vacuum and drying time during drying process
b. Check for completeness of drying by periodic monitoring of dryness
c. Certification of all test results

29.1.7. **Assembled Reactor**

a. Check completed reactor against approved outline drawings, provision for all fittings, finish level etc
b. Jacking test with oil on all the assembled reactors
c. Dye penetration test shall be carried out after the jacking test

29.1.8. **Bought Out Items**

The make of all major bought out items shall be subject to Purchaser's approval. The Contractor shall also prepare a comprehensive inspection and testing programme for all bought out/sub-contracted items and shall submit the same to the Purchaser for approval. Such programme shall include the following components:

a) Buchholz Relay
b) Axles and wheels
c) Winding temperature indicators for local and remote mounting
d) Oil temperature indicators
e) Bushings
f) Bushing current transformers
g) Individual Marshalling box and common marshalling box for a bank of three 1-Phase units
h) Radiators
i) Pressure relief device

Following routine tests shall be conducted on PRD.

f) Air pressure test
g) Liquid pressure test
h) Leakage test
i) Contact operation test
j) Dielectric test on contact terminals

The above list is not exhaustive and the Contractor shall also include other bought-out items in his programme.

29.2. **Factory Tests**

The manufacturer shall be fully equipped to perform all the required tests as specified. Bidder shall confirm the capabilities of the proposed manufacturing plant in this regard when submitting the bid. Any limitations shall be clearly stated in.

The contractor shall bear all additional costs related to tests which are not possible to carry out at his own works.

The contractor shall submit an Inspection and test plan (ITP) for approval. A typical test plan is indicated in "**Annexure-B".**

All tests shall be done in line with IEC: 60076 and the test procedures as mentioned in "**Annexure-B".** Complete test report shall be submitted to purchaser after proper scrutiny and signing on each page by the test engineer of the contractor.

29.3. **Type Tests on fittings:**

All the following fittings shall conform to type tests and the type test reports shall be furnished by the contractor along with the drawings of equipment/ fittings as per the Chapter – GTR. The list of fittings and the type test requirement is:

1) Bushing (Type Test as per IEC:60137 including Snap back/Seismic test for 400 kV and above voltage class bushing)
2) Bus post insulators
3) Buchholz relay
4) Marshalling & common marshalling box (IP-55 test)
5) Pressure Relief device Test (including IP 55 test in terminal box)
6) Sudden Pressure Relay Test (including IP 55 test in terminal box)
7) Magnetic Oil Level gauge & Terminal Box for IP-55 degree of protection.
8) Air Cell (Flexible air separator) - Oil side coating, Air side under Coating, Air side outer coating and coated fabric as per IS: 3400/ BS: 903/ IS: 7016
9) OTI & WTI

29.4. **Pre-Shipment Checks at Manufacturer's Works**

29.4.1. Check for inter-changeability of components of similar reactor for mounting dimensions.

29.4.2. Check for proper packing and preservation of accessories like radiators, bushings, dehydrating breather, rollers, buchholz relay, fans, control cubicle, connecting pipes, conservator etc.

29.4.3. Check for proper provision for bracing to arrest the movement of core and winding assembly inside the tank.

29.4.4. Gas tightness test to confirm tightness and record of dew point of gas inside the tank. Derivation of leakage rate and ensure the adequate reserve gas capacity.

29.5. **Inspection and Testing at Site**

The Contractor shall carry out a detailed inspection and testing programme for field activities covering areas right from the receipt of material stage up to commissioning stage. An indicative programme of inspection as envisaged by the Purchaser is given below. However, it is contractor's responsibility to draw up and carry out such a programme duly approved by the Purchaser. Testing of oil sample at site shall be carried out as per specification. Contractor shall follow EMPLOYER Field Quality Plan (FQP).

29.6. **Receipt and Storage Checks**

29.6.1. Check and record condition of each package, visible parts of the reactor etc. for any damage.

29.6.2. Check and record the gas pressure in the reactor tank as well as in the gas cylinder.

29.6.3. Visual check for wedging of core and coils before filling up with oil and also check conditions of core and winding in general.

29.6.4. Check and record reading of impact recorder at receipt and verify the allowable limits as per manufacturer's recommendations.

29.7. **Installation Checks**

29.7.1. Check whole assembly for tightness, general appearance etc.

29.7.2. Oil leakage test

29.7.3. Capacitance and tan delta measurement of bushing before fixing/connecting to the winding, contractor shall furnish these values for site reference.

29.7.4. Leakage check on bushing before erection.

29.7.5. Measure and record the dew point of gas in the main tank before assembly.

29.8. **Commissioning Checks**

29.8.1. Check the colour of silicagel breather.

29.8.2. Check the oil level in the breather housing, conservator tanks, cooling system, condenser bushing etc.

29.8.3. Check the bushing for conformity of connection to the lines etc,

29.8.4. Check for correct operation of all protection devices and alarms/trip :

i. Buchholz relay
ii. Excessive winding temperature
iii. Excessive oil temperature
iv. Low oil flow
v. Low oil level indication

29.8.5. Check for the adequate protection on the electric circuit supplying the accessories.

29.8.6. Check resistance of all windings on all steps of the tap changer. Insulation resistance measurement for the following:

i) Control wiring
ii) Main windings
iii) Bushing current transformer

29.8.7. 2 kV/minute test between bushing CT terminal and earth.

29.8.8. Check for cleanliness of the reactor and the surroundings

29.8.9. Measure vibration and noise level

29.8.10. Capacitance and Tan delta measurement of winding and bushing

29.8.11. Frequency response analysis (FRA). FRA equipment shall be arranged by purchaser.

29.8.12. DGA of oil just before commissioning and after 24 hours energization at site.

29.8.13. Contractor shall prepare a comprehensive commissioning report including all commissioning test results as per Pre-Commissioning Procedures and forward to Purchaser for future record.

Annexure – A

1.0 Technical Particulars / Parameters of 420kV Shunt Reactor

Clause No.	Description	Unit	Parameters
1.1	Rated Voltage, U_r (1p.u)	kV	420
1.2	Rated Capacity at 420 kV	MVAR	50
1.3	Standard		IEC 60076-6
1.4	Connection (3 Phase)		Star
1.5	Cooling System		ONAN
1.6	Frequency	Hz	50
1.7	No of Phases		3 (THREE)
1.8	Service		Outdoor
1.9	System Fault Level	kA	50
1.10	Permissible current unbalance among different phases	%	±2
1.11	Crest value of Third Harmonic content in phase current at rated voltage with sinusoidal wave form	%	≤ 3% of the crest value of fundamental
1.12	Range of constant Impedance (However, complete saturation characteristics of the Reactors up to 2.5 p.u. Voltage shall be furnished)		Up to 1.5 p.u. voltage
1.13	Tolerance on current	%	0 to +5%
1.14	Ratio of zero sequence reactance to positive reactance (X0/X1)	Range	0.9 - 1.0
1.15	Temperature rise over 50 deg C Ambient Temp at rated voltage		
	Top oil measured by thermometer	^{O}C	40
	Average winding measured by resistance method	^{O}C	45
1.16	Max. design Ambient temp	^{O}C	50
1.17	Windings		
a)	Lightning Impulse withstand Voltage		
	HV	kV_p	1300
	Neutral	kV_p	170
b)	Switching Impulse withstand Voltage		
	HV	kV_p	1050
c)	Power Frequency withstand Voltage		
	Neutral	kV_{rms}	70
d)	Tan delta of windings		< 0.005
1.18	Bushing		
a)	Rated voltage		
	HV	kV	420
	Neutral	kV	36
b)	Rated current (Min.)		
	HV	A	800
	Neutral	A	800

Clause No.	Description	Unit	Parameters
c)	Lightning Impulse withstand Voltage		
	HV	kVp	1425
	Neutral	kVp	170
d)	Switching Impulse withstand Voltage		
	HV	kVp	1050
e)	Power Frequency withstand Voltage		
	HV	kVrms	695
	Neutral	kVrms	77
f)	Minimum total creepage distances		
	HV	mm	10500
	Neutral	mm	900
g)	Tan delta of bushings		
	HV		< 0.004
h)	Max Partial discharge level at U_m		
	HV	pC	10
	Neutral	pC	10
1.19	Maximum Partial discharge level at 1.58 $U_r / \sqrt{3}$	pC	100
1.20	Vibration and Tank stress level at rated voltage and frequency		Max : ≤ 200 microns peak to peak Average: ≤60 microns peak to peak. Stress: ≤ 2.0kg/sq.mm at any point on tank.
1.21	Maximum Noise level at rated voltage and frequency	dB	80

Notes:

Tan delta of Winding & Bushing shall be measured at ambient temperature. No temperature correction factor shall be applied.

Annexure -B

Test Plan

No.	Item	Test Category
1.	Measurement of winding resistance	Routine
2.	Reactance and loss measurement (Measured in Cold and Hot state for the unit on which temperature rise test is performed & in Cold state for all other units)	Routine
3.	Measurement of insulation resistance & Polarization Index	Routine
4.	Measurement of insulation power factor and capacitance between winding and earth	Routine
5.	Measurement of insulation power factor and capacitance of bushings	Routine
6.	Chopped wave lightning impulse test for the line terminals (LIC)	Routine
7.	Lightning impulse test on Neutral	Routine
8.	Switching impulse test	Routine
9.	Applied voltage test (AV)	Routine
10.	Induced Over Voltage Test with Partial Discharge Measurement	Routine
11.	Gas-in-oil analysis	Routine
12.	Oil leakage test on Reactor tank	Routine
13.	Appearance, construction and dimension check	Routine
14.	Frequency Response analysis (Soft copy of test report to be submitted to site along with test reports)	Routine
15.	High voltage with stand test on auxiliary equipment and wiring after assembly	Routine
16.	2-Hour excitation test except type tested unit	Routine
17.	Tank vacuum test	Routine
18.	Tank pressure test	Routine
19.	Vibration & stress measurement in Cold and Hot state for the unit on which temperature rise test is performed & in Cold state for all other units (Measurement shall also be carried out at 1.05Ur for reference only on one unit of each type)	Routine
20	Core assembly dielectric and earthing continuity test	Routine
21.	Temperature rise test	Type
22.	Measurement of harmonic content of current (Measured in Cold state)	Type
23.	Measurement of acoustic noise level (Measured in Cold and Hot state of temperature rise test)	Type
24.	Knee point voltage measurement of reactor (Measured in Cold state)	Type
25.	Measurement of zero-sequence reactance (Applicable for three phase shunt reactor only)	Type

Annexure - C

Test Procedures

1. Reactance and loss measurement

The type tested unit shall be measured in the cold and hot state. In other units, measurement shall be carried out in the cold state and corrected as per factors derived from the type tested unit.
Measurement shall also be carried out during 2-hour excitation test.

The following details shall be recorded under the heading of losses on the test certificate:

the voltage readings taken;
the mode of response and scaling of the voltmeters;
the current reading;
the power reading;
total losses measured;
Total losses corrected to 75°C winding temperature
the frequency reading ;
the instrument constants and corrections (if any);
The magnetization **curve of the reactor (Type tested unit).**

2. Core assembly dielectric and earthing continuity tests.

The insulation of the magnetic circuit, and between the magnetic circuit and the core clamping structure, including core-bolts, bands and/ or buckles shall withstand the application of a test voltage of either 2 kVac or 3 kV dc for 60 seconds.

The insulation of core to tank, core to yoke clamp (frame) and yoke clamp (frame) to tank shall be able to withstand a voltage of 2 kV (DC) for 1 minute. Insulation resistance shall be minimum 1 GΩ for all cases mentioned above.

The continuity of the single-point earthing shall be verified before despatch. The results of the works tests shall be recorded on the test certificate, and shall include the resistance reading obtained from a measurement made between the core and core clamping structure by means of at least 1.5 kV ac or 2 kV dc. During erection, the contractor shall repeat this measurement at site. The records of these tests shall also be included in the test report.

3. Two hours excitation test

Each reactor to be excited at 1 p.u. for 2 hours except type tested unit.
Measure reactance, loss and vibration
DGA rate interpretation shall be as per IEC/ CIGRE/ IEEE guidelines

4. **Temperature rise test** (As per IEC-60076)

Temperature rise shall be guaranteed and tested at rated voltage (1 p.u).

DGA tests shall be performed before and after heat run test and DGA results shall generally conform to IEC61181.

During this test the following shall be measured.

- Reactance and loss
- Audible sound
- Vibration
- Colour photographs of the four sides and top of the reactor together with the corresponding series of thermal images (colour) during starting and end of the test. It is also recommended to take thermal images 4 more times to take care of any unforeseen situation.
- Temperature measurement with internal probes during test.

The heat run type test results shall serve as a "finger print" for the other units to be routine tested.

The tests shall be done for a minimum of 24 hours with saturated temperature for at least 4 hours.

Full details of the test arrangements, procedures and conditions shall be provided with the test certificates and the following shall at least be included.

Purchaser's order number and reactor site designation.
Manufacturer's name and reactor serial number.
Ratings of reactor:
MVA Voltage:
Frequency
Rated currents:
Class of cooling
Measured load losses at 75° C.
Altitude of test bay.

Top oil temperature rise test

A log of the following parameters taken at 30 minute intervals:
time
Voltage
Current
Total power
Ambient temperature measured on not less than three thermometers
Top oil temperature: and
Cooler inlet and outlet oil temperatures.

Winding temperature rise test

Log the half–hourly readings of the parameters as for the top oil temperature rise test.

Provide a table of readings, after shut-down of power, giving the following information;

Time after shut- down:
Time increment:

Winding resistance: Record the resistance values for minimum 20 minutes.

Provide a record of all calculations, corrections and curves leading to the determination of the winding temperatures at the instant of shut-down of power.

Record any action taken to remedy instability of the oil surge device during initiation of the oil circulating pumps.

Temperature measurements as per special probes or sensors placed at various locations shall also be recorded.

5. Tank Vacuum Tests

All shunt reactor tanks shall be subjected to the specified vacuum. The tank designed for full vacuum shall be tested at an internal pressure of 3.33 KN/sq.m absolute (25 torr) for one hour. The permanent deflection of flat plates after the vacuum has been released shall not exceed the values specified below:

Horizontal length of flat plate (in mm)	Permanent deflection (in mm)
Upto and including 750	5.0
751 to 1250	6.5
1251 to 1750	8.0
1751 to 2000	9.5
2001 to 2250	11.0
2251 to 2500	12.5
2501 to 3000	16.0
above 3000	19.0

6. Tank Pressure Test

All shunt reactor tanks of each size ,its radiator, conservator vessel and other fittings together or separately shall be subjected to a pressure corresponding to twice the normal head of oil or normal oil head pressure plus 35 KN/sq.m whichever is lower, measured at the base of the tank and maintained for one hour. The permanent deflection of the flat plate after the excess pressure has been released shall not exceed the figures specified above for vacuum test.

7. Oil leakage test on reactor tank

All tanks and oil filled compartments shall be completely filled with air or oil of a viscosity not greater than that of insulating oil conforming to IEC 60296 at the ambient temperature and subjected to a pressure equal to normal head of oil plus 35 kN/sq.m(5 psi) measured at the base of the tank. This pressure shall be maintained for a period of not less than 12 hours for oil and 1 hour for air during which no leakage shall occur.

8. **Routine tests on Bushings:** Routine test on bushings shall be done as per IEC 60137.

Annexure – D

Design Review Document for Shunt Reactor

Sr. No.	Description
1.	Core and Magnetic Design
2.	Over-fluxing and Linear characteristics
3.	Inrush-current characteristics while charging
4.	Winding and winding clamping arrangements
5.	Short-circuit withstand capability considering inrush current.
6.	Thermal design including review of localised potentially hot area
7.	Cooling design
8.	Overload capability
9.	Eddy current losses
10.	Seismic design, as applicable
11.	Insulation co-ordination
12.	Tank and accessories
13.	Bushings
14.	Protective devices
15.	Radiators
16.	Sensors and protective devices– its location, fitment, securing and level of redundancy
17.	Oil and oil preservation system
18.	Corrosion protection
19.	Electrical and physical Interfaces with substation
20.	Earthing (Internal & External)
21.	Processing and assembly
22.	Testing capabilities
23.	Inspection and test plan
24.	Transport and storage
25.	Sensitivity of design to specified parameters
26.	Acoustic Noise
27.	Spares, inter-changeability and standardization
28.	Maintainability
29.	PRD and SPR (number & locations) and selection
30.	Conservator capacity calculation
31.	Winding Clamping arrangement details with provisions for taking it "in or out of tank"
32.	Conductor insulation paper details
33.	Location of Optical temperature sensors
34.	The design of all current connections
35.	Location & size of the Valves

Annexure – E

Painting Procedure:

PAINTING	Surface preparation	Primer coat	Intermediate undercoat	Finish coat	Total dry film thick-ness (DFT)	Colour shade
Main tank, pipes, conservator tank, oil storage tank & DM Box etc. (external surfaces)	Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40 m)	Epoxy high build Micaceous iron oxide (HB MIO) (75 m)	Aliphatic polyurethane (PU) (Minimum 50 m)	Minimum 155 m	RAL 7035
Main tank, pipes (above 80 NB), conservator tank, oil storage tank & DM Box etc. (Internal surfaces)	Shot Blast cleaning Sa 2 ½*	Hot oil proof, low viscosity varnish or Hot oil resistant, non-corrosive Paint	--	--	Minimum 30 m	Glossy white for paint
Radiator (external surfaces)	Chemical / Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40 m)	Epoxy base Zinc primer (30-40 m)	PU paint (Minimum 50 m)	Minimum 100 m	Matching shade of tank/ different shade aesthetically matching to tank
	contractor may also offer Radiators with hot dip galvanised in place of painting with minimum thickness of 40 m (min)					
Radiator and pipes up to 80 NB (Internal surfaces)	Chemical cleaning, if required	Hot oil proof, low viscosity varnish or Hot oil resistant, non-corrosive Paint	--	--	--	--
Control cabinet / Marshalling Box/Common Marshalling Box - No painting is required.						

Note: (*) indicates Sa 2 ½ as per Swedish Standard SIS 055900 of ISO 8501 Part-1.

Annexure – F

Unused inhibited Insulating Oil Parameters

SN	Property	Test Method	Limits
A	**Function**		
1a	Viscosity at 100degC	ISO 3104 or ASTM D445 or ASTM D7042	(Max.) 3 mm2/s
1b	Viscosity at 40degC	ISO 3104 or ASTM D445 or ASTM D7042	(Max.) 12 mm2/s
1c	Viscosity at -30degC	ISO 3104 or ASTM D445 or ASTM D7042	(Max.) 1800 mm2/s
2	Appearance	A representative sample of the oil shall be examined in a 100 mm thick layer, at ambient temperature	The oil shall be clear and bright, transparent and free from suspended matter or sediment
3	Pour point	ISO 3016 or ASTM D97	(Max.)- 40degC
4	Water content a) for bulk supply b) for delivery in drums	IEC 60814 or ASTM D1533	Max.) 30 mg/kg 40 mg/kg
5	Electric strength (breakdown voltage)	IEC 60156	(Min.)50 kV(new unfiltered oil) / 70 kV (after treatment)
6	Density at 20 deg C	ISO 3675 or ISO 12185 or ASTM D 4052	0.820 - 0.895 g/ml
7	Dielectric dissipation factor (tan delta) at 90 deg C	IEC 60247 or IEC 61620 Or ASTM D924	(Max) 0.0025
8	Negative impulse testing KVp @ 25 deg C	ASTM D-3300	145 (Min.)
9	Carbon type composition (% of Aromatic, Paraffins and Naphthenic compounds)	IEC 60590 and IS 13155 or ASTM D 2140	Max.Aromatic : 4 to12 % Paraffins : <50% & balance shall be Naphthenic compounds.
B	**Refining/Stability**		
1	Acidity	IEC 60590 and IS 13155 or ASTM D 2140	(Max) 0.01 mg KOH/g
2	Interfacial tension at 27degC	ISO 6295 or ASTM D971	(Min) 0.04 N/m
3	Total sulphur content	BS 2000 part 373 or ISO 14596 or ASTM D 2622 or ISO 20847	0.05 % (Max.) (before oxidation test)

SN	Property	Test Method	Limits
4	Corrosive sulphur	IEC 62535	Non-Corrosive on copper and paper
		ASTM D1275B	Non-Corrosive
5	Presence of oxidation inhibitor	IEC 60666 or ASTM D2668 or D4768	0.08% (Min.) to 0.4% (Max.) Oil should contain no other additives .Supplier should declare presence of additives, if any.
6	2-Furfural content	IEC 61198 or ASTM D5837	25 Microgram/litre (Max.)
C	**Performance**		
1	Oxidation stability -Total acidity -Sludge - Dielectric dissipation factor (tan delta) at 90degC	IEC 61125 (method c) Test duration 500 hour IEC 60247	 Max 0.3 mg KOH/g Max 0.05 % Max 0.05
2	Oxidation stability	ASTM D2112 (a)	220 Minutes (Min.)
D	**Health, safety and environment (HSE)**		
1	Flash point	ISO 2719	(Min.)135deg C
2	PCA content	BS 2000 Part 346	Max 3%
3	PCB content	IEC 61619 or ASTM D4059	Not detectable (Less than 2 mg/kg)
E	**Oil used (inhibited) for first filling, testing and impregnation of active parts at manufacturer's works shall meet parameters as mentioned below:**		
1	Break Down voltage (BDV)		70kV (min.)
2	Moisture content		5 ppm (max.)
3	Tan-delta at 90°C		0.005 (max)
4	Interfacial tension		0.04 N/m (min)
F	**Each lot of the oil shall be tested prior to filling in main tank at site for the following:**		
1	Break Down voltage (BDV)		70 kV (min.)
2	Moisture content		5 ppm (max.)
3	Tan-delta at 90°C		0.0025 (Max)
4	Interfacial tension		More than 0.04 N/m
G	**After filtration & settling and prior to energisation at site oil shall be tested for following:**		
1	Break Down voltage (BDV)	IS: 1866 / IEC 60422	70 kV (min.)
2	Moisture content at		5 ppm (max.)

SN	Property	Test Method	Limits
	hot condition		
3	Tan-delta at 90°C		0.005 (Max)
4	Interfacial tension		More than 0.04 N/m
5	*Oxidation Stability	Test method as per IEC	
	a) Acidity	61125 method C,	0.3 (mg KOH /g) (max.)
	b) Sludge	Test duration: 500hour for inhibited oil	0.05 % (max.)
	c) Tan delta at 90 °C		0.05 (max.)
6	*Total PCB content		Not detectable (less than 2 mg/kg total)
	*** Separate oil sample shall be taken and test results shall be submitted within 45 days after commissioning for approval of Employer.**		

Annexure – G

Technical Parameters of Current Transformers - 420 kV Shunt Reactor
On each phase connection

(a) Ratio	**Shunt Reactor**		
	Line Side	Neutral Side	Common Neutral Side
CORE 1	200/1A	200/1A	200/1A
CORE 2	200/1A	To be decided by contractor for WTI	
CORE 3	200/1A	2000-1000-500/1A	
CORE 4	200/1A	2000-1000-500/1A	
CORE 1	200V, TPS Class	200V, TPS Class	200V, TPS Class
CORE 2	200V, TPS Class	To be decided by contractor for WTI	
CORE 3	200V, TPS Class	1000-500-250V, TPS Class	
CORE 4	10VA, Class 1.0	1000-500-250V, TPS Class	
CORE 1	1 Ohm	1 Ohm	1 Ohm
CORE 2	1 Ohm	-	
CORE 3	1 Ohm	10-5-2.5 Ohm	
CORE 4		10-5-2.5 Ohm	
CORE 1	Reactor Differential	Reactor Differential	Restricted earth fault
CORE 2	Restricted earth fault	Temperature Indicator (on one phase only)	
CORE 3	Reactor Backup	Line Protection (Main-I)/T zone differential Protection/spare	
CORE 4	Metering	Line Protection (Main-II)/T zone differential Protection/spare	

NOTE:

i) For TPS class CT's, Dimensioning parameter "K", Secondary VA shall be considered 1.5 and 20 respectively.

ii) Rated continuous thermal current rating shall be 200% of rated primary current.

iii) Parameters of WTI CT for each winding shall be provided by the contractor.

iv) For estimation of spares, one set of CTs shall mean one CT of each type used in Reactor.

v) The CT used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection.

ANNEXURE - H

Technical Specification of Oil BDV Test Set

Item	**Specification**
Functional Requirement	1. The instrument should be suitable for Automatic Measurement of Electrical Breakdown Strength of Reactor oil as per relevant standards. 2. The test results should have repeatability, consistency in laboratory condition.
Test Output	0-100 kV (Rate of rise: 0.5 to 5KV/Sec)
Accuracy	± 1 kV
Resolution	0.1 KV
Switch off Time	≤ 1ms
Display/Control	LCD/Keypads.
Printer	Inbuilt/External
Measurement Programmes	Fully Automatic Pre-programmed/User programmed Test Sequences including as per latest IEC & other national/international standards.
Test Lead/ Accessories	One complete set of electrodes, gauge etc. compatible with the instruments should be provided for successfully carrying out the test in EMPLOYER S/S. Additionally all the required accessories, tools, drawing, documents should be provided for the smooth functioning of kit. Further hard carrying case (which should be robust/ rugged enough) for ensuring proper safety of the kit during transportation shall have to be provided.
Design/Engg.	The complete equipment along with complete accessories must be designed / engineered by Original Equipment Manufacturer.
Power Supply	It shall work on input supply variations, V: 230 ±10 %, f: 50 Hz ±5 % on standard sockets.
Operating Temperature	0 to +50 deg C
Relative humidity	Max. 90% non-condensing.
Protection/ Control	Against short circuit, over load, transient surges etc. Also the instrument should have facility of stopping automatically on power failure. Also the kit should have facility of HV chamber interlocking as well as zero start interlocking.
Display/Control	LCD/keypads.
Environment	The test kit shall be compatible for EMI/EMC/Safety environment requirement as per IEC.
Guarantee	Warranty/Guarantee Period: Min 01 year from the date of successful & complete commissioning at Employer sub-station. All the materials, including accessories, cables, laptops etc. are to be covered under warranty/guaranty period. If the kit needs to be shifted to supplier's works for repairs within warranty/guaranty period, suppliers will have to bear the cost of spares, software, transportation of kit for repair at test lab / works.
Calibration Certificate	Unit shall be duly calibrated before supply and the date of calibration shall not be older than two month from the date of supply of Kit.
Training	Supplier shall have to ensure that the instrument is made user friendly. Apart from the detailed demonstration at site, the supplier shall also have to arrange necessary training to EMPLOYER engineers.
Commissioning, handing over the Instrument	Successful bidder will have to commission the instrument to the satisfaction of EMPLOYER. The instrument failed during the demonstration shall be rejected and no repairs are allowed.

Technical Specification of Portable Dissolved Gas Analysis of Oil

ANNEXURE - I

<table>
<tr><th>SN</th><th>Particulars</th><th>Specification</th></tr>
<tr><td>01</td><td>Functional Requirement</td><td>The Portable Gas Chromatograph equipment to extract, detect, analyze and display the dissolved gases in Reactor oil as specified in IEEE C 57-104-1991 and IEC 60559-1999.</td></tr>
<tr><td>02</td><td>Extraction of Gases</td><td>Gases shall be extracted from insulating oil either of the mercury free extraction method
- Shake test method as described in IEC-60567-2005-Annexure C
- Head space method
- Partial Degassing toepler pump method</td></tr>
<tr><td>03</td><td>Detection of Gases</td><td>The gases extracted as above shall be detected using either portable GC with TCD/FID/any other detector or using spectroscopic method. All the fault gases ie H_2, CH_4, C_2H_2, C_2H_4, C_2H_6, CO&CO_2 concentrations shall be individually measured and displayed. It is preferable that instrument also displays N_2 and O_2 content individually. The minimum detection limits of the instrument shall be strictly met the requirement of IEC-60567-2005-Page No.81-clause 9.2, table-5.</td></tr>
<tr><td>04</td><td>Performance Parameters</td><td>
<table>
<tr><td>Gases</td><td>Minimum Detection Limits in ppm</td><td>Working Range in ppm</td><td>Accuracy</td></tr>
<tr><td>Hydrogen-H_2</td><td>5</td><td>0-5000</td><td rowspan="4">+/- 2 ppm or +/- 5% whichever is greater</td></tr>
<tr><td>Hydrocarbons-CH_4, C_2H_2, C_2H_4, C_2H_6</td><td>1</td><td>0-10000</td></tr>
<tr><td>Carbon Monoxide-CO</td><td>25</td><td>0-10000</td></tr>
<tr><td>Carbon dioxide-CO_2</td><td>25</td><td>0-50000</td></tr>
</table>
</td></tr>
<tr><td>05</td><td>Power Supply</td><td>It shall be operated with AC single phase, 50 Hz +/-5%, 230 V +/- 10% supply. All power cable and necessary adaptors shall be provided by supplier.</td></tr>
<tr><td>06</td><td>Calibration</td><td>a) Instrument shall have facility to perform calibration check using GAS-IN-OIL standards as well as calibration gas mixtures. This GAS-IN-OIL standard shall be prepared in syringes in accordance with IEC-60567-2005-Page No.35-clause 6.2.
b) The calibration shall be demonstrated by supplier at the time of installation/commissioning at our lab and EMPLOYER will provide only the insulating oil for testing.
c) All necessary requirements like Glass syringes, 3 way cock and any other consumable required for calibration check shall include in the scope of supply.</td></tr>
</table>

07	Instrument control and Data handling, Internal Memory	a) In case laptop is essential for operating the instrument, it shall be of latest specification along with licensed preloaded OS and software as well as software for interpreting DGA results accordance with IEEE C 57-104-1991 and IEC 60559-1999 along with laptop with carrying case included b) In case instrument is having in-built control for all the
		functions (data acquisitions and data storage), it shall have a facility for communication with computer for downloading the data from instrument via USB port. Licensed copy of the software required to download data to computer shall be provided. c) Internal Memory can capable of store 15000 records, if inbuilt functions
08	General Conditions	All required items/instruments /spares /consumable /connecting cables/communicationcables/instruments/manuals/Certificates/training materials/original software/original licensed data//station operating software/education CD/DVDs that are essential to understand the basics and advanced gas chromatography and in parts/items that are essential to complete the supply, installation and commissioning the system required in the international standards ASTM-D-3612/2002 Method C / IEC-60567-05 shall be supplied to our laboratory in healthy condition and no extra cost.
09	Operating Temperature, Relative humidity & Dimensions	01. Temperature 0-40 Deg. C 02. 85% non condensing 03. Portable
10	Receipt, Storage	It shall be the responsibility of the supplier to ensure proper receipt and storage before commissioning the kit.
11	Warranty	The entire test set up shall be covered on warranty for a period of one year from the last date of complete commissioning and taking over the test set up. If the kit needs to be shifted to suppliers works for repairs, supplier will have to bear the cost of, spares, software, transportation etc of kit for repair at test lab/works.
13	Application Note	An application note/principle document from original manufacturer compliance with standard test method shall be submitted along with the kit.
14	Service Support	The supplier shall furnish the detailed organization structure of the service team, who has acquired qualification and regular training records from manufacturer. Mode of attending service calls shall be given in details.
15	Training	The supplier shall arrange complete training by an application scientist who acquired technical & academic capacity of the principle company in the premises of our Laboratory for a period of two working days. The required reading materials/CDs shall be arranged by the supplier.
16	Spares and consumables	All the necessary spares and consumables including carrier gas bottles if required, calibration gas mixture, septa, syringes, 3 way valves etc to run the equipment for AMC period with sample load of around 500 samples per year shall be offered items and quantity wise.

ANNEXURE - J

Nitrogen Injection Type Fire Prevention & Extinguishing System

1.1 Nitrogen Injection Type Fire Protection System (NIFPS) shall be designed to prevent explosion of transformer/reactor tank and the fire during internal faults resulting from arc.

The system shall work on the principle of Drain & stir. On activation, it shall drain a pre-determined quantity of oil from the tank top through drain valve to reduce the tank pressure, isolate conservator tank oil and inject nitrogen gas at high pressure from the bottom side of the tank through inlet valves to create stirring action and reduce the temperature of oil below flash point to extinguish the fire. On operation, the quantity of oil removed from the tank shall be such that adequate amount of oil shall remain to cover active part (i.e. core coil assembly).

Electrical isolation of transformer/reactor shall be an essential pre-condition for activating the system.

1.2 Operational Controls

The system operation shall be fully automatic and activate from the required fire and other trip signals. In addition to automatic operation, remote operation from control room/ remote centre and local manual control in the fire extinguishing cubicle shall also be provided. System shall operate on following situations:

1.2.1 Prevention of transformer/reactor from explosion and fire

To prevent transformer/reactor from explosion and fire in case of an internal fault, signals given by operation of Electrical protection relays and tripping of circuit breaker of transformer/reactor and operation of either Buchholz relay or pressure relief valve (PRV) shall be used to activate the system. The exact logic for system activation shall be finalized during detailed engineering.

1.2.2 Prevention of transformer/reactor from fire

In case of fire, sensed by fire detectors, the system shall be activated only after electrical isolation of the transformer/reactor, confirmed by breaker trip. If the fire detection is not associated with any other fault, the system activation shall be only manual. Manual operation switch shall be provided in the control room with a cover to avoid accidental operation of it.

1.3 Operation of System

On receiving activation signal, the following shall take place:

i) Open the quick opening drain valve to drain the top layer oil

ii) Shut off the conservator isolation valve to prevent flow of oil from the Conservator tank to the main tank

iii) Open the Nitrogen regulator valve to inject Nitrogen into the transformer/reactor tank to create stirring of oil.

There shall be interlock to prevent activation of the system if the transformer/reactor is not electrically isolated.

There shall also be provision for isolating the system during maintenance and/or testing of the transformer/reactor.

1.4 Technical Particulars

The contractor shall be responsible for the design of the complete system and shall submit the drawings and design calculations for the number of fire detectors, pipe sizing of drain pipe and Nitrogen injection pipe, Nitrogen cylinder capacity, number of injection points, etc. and get approval from EMPLOYER.

Facility shall be provided to test the system when the transformer/reactor is in service, without actually draining the oil and injecting Nitrogen.

The Nitrogen regulator valve shall be designed in such a way that the Nitrogen shall not enter the transformer/reactor tank even in case of passing/ leakage of valve.

Owner shall provide two distinct station auxiliary DC feeders for control purposes. The system shall work on station DC supply with voltage variation defined in GTR .The control box of fire protection system shall have facility to receive these feeders for auto changeover of supply. It shall be the contractor's responsibility to further distribute power to the required locations. In case auxiliary DC power supply requirement is different than station auxiliary DC supply, then all necessary DC-DC converters shall be provided by the Contractor.

Following minimum indications and alarms shall be provided in the local cubicle as well as in the control box:-

- Nitrogen cylinder pressure indication - manometer with sufficient number of adjustable NO contacts
- Nitrogen cylinder
  pressure low Fire in
  Transformer/ Reactor
  Oil drain started
- Conservator oil isolation valve closed
- Nitrogen injection started
- DC supply fail
- Oil drain valve closed
- Gas inlet valve closed

1.5 Details of Supply of System Equipments and Other Related Activities:

The scope of supply shall include the following items and any other items required for safe and trouble free operation of the system.

i) Fire extinguishing cubicle with base frame and containing at least the following:

Nitrogen gas cylinder of sufficient capacity with pressure regulator and manometer with sufficient number of adjustable NO contacts. Oil Drain Assembly including oil drain pipe extension of suitable size for connecting pipes to oil pit Mechanical release device for oil drain and nitrogen release Limit switches for monitoring of the systems Panel lighting Flanges on top of the panel for connecting oil drain and nitrogen injection pipes for transformer/reactor Back up pressure switch to operate nitrogen gas valve Pressure indicators for Nitrogen pressure of the cylinder and actual injection through Nitrogen regulator

ii) Control box to be installed in the control room of the station for monitoring system operation, automatic control and remote operation, with alarms, indications, switches, push buttons, audio signal, suitable for tripping and signalling.

iii) Required number of fire detectors to be located in strategic locations to be finalized during detailed engineering.

iv) All controls, alarms, panels, cables, cable trays (if required), junction boxes etc.

1.6 Under Ground Oil Storage Tank

Each transformer/reactor unit shall be provided with an underground oil storage tank. The oil storage tank shall have Non Corrosive, water proof, epoxy coated (from Inside) mild steel (minimum thickness 6 mm) to store drained out oil on operation of NIFPS. The tank shall be painted from outside as per **Annexure – E**. The total capacity of storage tank shall be atleast 10% of transformer/reactor tank oil to avoid overflowing of oil considering that drained oil volume shall be around 10% of transformer/reactor tank oil. Necessary arrangement shall be made on underground storage tank so as to take out the drained oil from the tank for further processing and use. All the pipe and physical connection from transformer/reactor to oil pit shall be in the scope of contractor.

This storage tank shall be placed in the pit made of brick walls with PCC (1:2:4) flooring with suitable cover plates to avoid ingress of rain water. The design of tank and pit shall be finalised during detailed engineering.

1.7 Installation and pre-commissioning test

After installation the system pre-commissioning tests shall be carried out jointly with the Owner’s representative before the system is put in service.

1.8 NIFPS based on alternate proven technology shall also be acceptable.

ANNEXURE – K

Online Dissolved Gas (Multi-gas) and Moisture Analyzer

1.1. Online Dissolved Gas (Multi-gas) and Moisture Analyser along with all required accessories shall be provided with each reactor for measurement & analysis of dissolved gases and moisture in the oil. Interpretations shall be as per IEC 60599-1999.

1.2. The equipment shall detect measure and analyse the following gases:

Gases & Moisture Parameters	Typical Detection Range
H_2	5 – 5,000 ppm
CH_4	5 – 5,000 ppm
C_2H_6	5 – 5,000 ppm
C_2H_4	3 – 5,000 ppm
C_2H_2	1 – 3,000 ppm
CO	10 – 10,000 ppm
CO_2	20 – 30,000 ppm
O_2 (Optional)	500 – 25,000 ppm
H_2O	2 – 100 % RS should have facility for measurement of moisture in oil in ppm

1.3. The analyser should measure (not calculate) all above gases and should have 100% sensitivity. The equipment shall be capable of transferring data to sub-station automation system confirming to IEC 61850. Necessary interface arrangement shall be provided by the contractor for integration with automation system. The necessary type test report for such confirmation shall be submitted during detailed engineering.

1.4. Equipment shall havefacility to give SMS alert to at least three users whenever any fault gas violates the predefined limit.

1.5. Equipment should work on station auxiliary supply. In case other supply is required for the equipment then suitable converter shall be included. All the necessary power and control cables, communication cables, cable accessories as required shall be provided by the supplier.

1.6. Online DGA shall be installed out door on reactor in harsh ambient and noisy condition (Electromagnetic induction, Corona, and capacitive coupling). Equipment shall be mounted separately to avoid effect of vibration. Suitable arrangement shall be provided to support and protect the inlet and outlet piping arrangement.The equipment shall be suitable for proper operation in EHV substation (800kV) environment where switching takes place in the EHV/HV System. The suitable indications for power On, Alarm, Caution, normal operation etc. shall be provided on the front panel of the equipment. The equipment shall have IP55 Stainless Steelenclosure, suitable for 55 ^{0}C ambient temperature and EMI and EMC compatibility. The Equipment must carry a minimum of two (2) years manufacturer's Warranty.

1.7. The equipment shall connect to the reactor's main body in two locations. One Connection is for the supply of oil from the reactor. Second connection is for the return of the oil to the reactor. The connecting oil lines must be of Stainless Steel rigid pipes or flexible hoses.

1.8. The equipment shall be able to measure gas concentration and when downloaded should immediately compare it with user selected alarm & caution level for immediate display. The sampling rate shall be selectable as 2 or 4 or 6 or 12 hours etc. The equipment shall have inbuilt memory to store these results for complete one year even if sampling is done at the lowest interval.

1.9. The Equipment must have an automatic Calibration facility at fixed intervals. For calibration if anything required including cylinder must be mounted with the Equipment.

1.10. The technical feature of the equipment shall be as under:

Accuracy	$\pm$ 10%
Repeatability	$\pm$3% to 10% depending upon gases
Oil temperature range	- 20^0 C to + 120^0 C
External Temp. Range	- 20^0 C to + 55^0 C (External temp range of 55^0 C is important and should not be compromise due to Nepal(Terai region) ambient & operating conditions.)
Humidity range	10 to 95 %
Operating Voltage	230 Vac; 50 Hz (±20% variation)
Communications	USB&IEC 61850 compliant

1.11. Software for fault indication and fault diagnostics shall include following:
Fault indication:

i) IEEE, IEC or user configurable levels of dissolved gases
ii) Rate of change trending

Fault Diagnosis:

i) Key gases
ii) Ratios (Rogers, IEC. etc.)
iii) Duval's Triangle

1.12. The equipment shall be supplied with all necessary accessories required for carrying out DGA of oil sample complete in all respect as per the technical specification. The following shall be also form a part of supply.

i) Software
ii) Operation Manual (2 set for every unit),
iii) Software Manual and
iv) Compact disc giving operation procedures of Maintenance Manual & Trouble shooting instructions.

ANNEXURE - L

On Line Dissolved Hydrogen and Moisture Monitor

1.0 The Monitor shall be a microprocessor based Intelligent Electronic Device (IED), designed to continuously detect and measure dissolved Hydrogen and Water content, even at very low concentrations, in Reactor Oil. It should be easy to install and it should be possible to retrofit it on an energized reactor, without shutting down the reactor.

2.0 The monitor shall be designed for permanent outdoor use in high voltage sub-station environments, for ambient temperatures of -20 deg C to 55 deg C and oil temperatures of -20 deg C to 105 deg C.

3.0 The monitor shall be suitable to detect and measure dissolved Hydrogen in ppm, without significant interference from other fault and atmospheric gases. The monitor shall also be suitable to detect Water Content measured in ppm or % RS (Relative Saturation).

4.0 Equipment shall be mounted separately to avoid effect of vibration. Suitable arrangement shall be provided to support and protect the inlet and outlet piping arrangement. The equipment shall be suitable for proper operation in EHV substation (800kV) environment where switching takes place in the EHV/HV System.

5.0 The Hydrogen sensors shall have long lifetime in oil. The sensors shall be able to withstand pressure from vacuum to 10 psi.

6.0 Technical Parameters:

Sr. No.	**Parameters**	**Requirements**
a)	The measurement range / Output:	
	Hydrogen Dissolved in oil	0 to 2000 ppm, with 4 – 20 mA output
	Water Dissolved in oil	0 to 95% RS, with 4 – 20 mA output
b)	Alarms/Indication (High & Very High)	
	Hydrogen	Programmable NO/NC contacts,
	Water	Programmable NO/NC contacts,
c)	Environment	
	Operating Ambient Temperature	– 20 to + 55 deg C
	Operating Oil Temperature	– 20 to + 105 deg C
d)	Pressure Withstand, (Oil side)	Full Vacuum to 10 psi.
e)	Exterior enclosure and components	made of corrosion proof material to IP - 55
f)	Communications	RS–232 ports and suitable for Ethernet connectivity

Equipment shall be mounted separately to avoid effect of vibration. Suitable arrangement shall be provided support and protect the inlet and outlet piping arrangement.

ANNEXURE - M

On-line insulating oil drying system (Cartridge type)

In addition to provision of air cell in conservators for sealing of the oil system against the atmosphere, each shunt reactor shall be provided with an on line insulating oil drying system of adequate rating with proven field performance.

Equipment shall be mounted separately to avoid effect of vibration. Suitable arrangement shall be provided to support and protect the piping arrangement.The equipment shall be suitable for proper operation in EHV substation (800kV) environment where switching takes place in the EHV/HV System. This on line insulating oil drying system shall be

i. Designed for very slow removal of moisture that may enter the oil system or generated during cellulose decomposition. Oil flow to the equipment shall be controlled through pump of suitable capacity.

ii. The equipment shall display the moisture content in oil (PPM) of the inlet and outlet oil from the drying system.

iii. Minimum capacity of moisture extraction shall be 10 Litres before replacement of cartridge. Calculation to prove the adequacy of sizing of the on line insulating oil drying system along with make and model shall be submitted for approval of purchaser during detail engineering.

The equipment shall be supplied with Operation Manual (2 set for every unit), Software (if any), and Compact disc giving operation procedures of Maintenance Manual & Trouble shooting instructions.

CHAPTER 7: LT SWITCHGEAR

1.1. CONSTRUCTIONAL DETAILS OF SWITCHBOARDS AND DISTRIBUTION BOARDS

1.1.1. All boards shall be of metal enclosed, indoor floor mounted, compartmentalised double front construction and freestanding type.

1.1.2. All board frames, shall be fabricated using suitable mild steel structural sections or pressed and shaped cold-rolled sheet steel of thickness not less than 2.0 mm. Frames shall be enclosed in cold-rolled sheet steel of thickness not less than 1.6 mm. Doors and covers shall also be of cold rolled sheet steel of thickness not less than 1.6 mm. Stiffeners shall be provided wherever necessary. Gland plate shall be cold rolled sheet steel having thickness not less than 3 mm in all cases. However, in case of termination of single core power cables, gland plate shall be of non-magnetic material of at least 4mm thickness.

1.1.3. All panel edges and cover/door edges shall be reinforced against distortion by rolling, bending or by the addition of welded reinforcement members.

1.1.4. The complete structures shall be rigid, self-supporting, and free from flaws, twists and bends. All cut-outs shall be true in shape and devoid of sharp edges.

1.1.5. All boards shall be of dust and vermin proof construction and shall be provided with a degree of protection of IP: 52, for category I enclosure as per IEC 60947 (Part-1). However, the busbar chambers having a degree of protection of IP: 42, in accordance with IEC 60947 (Part-1), are also acceptable where continuous busbar rating exceeds 1000 Amp. Provision shall be made in all draw out Air Circuit Breaker compartments for providing IP: 52 degree of protection, when Circuit breaker trolley, has been removed. Panels with lighting transformers shall have IP 31 degree of protection in accordance with IEC 60947 (Part-1). Door frame of panels, meters, relays, Breaker cut-outs shall be provided with neoprene rubber gaskets generally conforming to IEC/International Standards.

1.1.6. Provision of louvers on boards would not be preferred. However, louvers backed with metal screen are acceptable on the busbar chambers where continuous busbar rating exceeds 1000 Amps. Panels with lighting transformers in lighting distribution boards shall have louvers.

1.1.7. All boards shall be of uniform height not exceeding 2450 mm.

1.1.8. Boards shall be easily extendible on both sides, by the addition of the vertical sections after removing the end covers of bus bar chambers.

1.1.9. Boards shall be supplied with base frames made of structural steel sections, alongwith all necessary mounting hardware required for welding the base frames to the insert plates.

1.1.10. a) All boards shall be of double front construction and shall have ÷

(i) A completely enclosed busbar compartment for running horizontal busbars and vertical busbars. Busbar chambers shall be completely enclosed with metallic portions. Bolted covers shall be provided for access to horizontal and Vertical busbars for repair and maintenance, which shall be feasible without disturbing feeder compartment. Vertical bus bar chambers shall be accessible from front as well as back side of the panel and shall be of at least 350 mm width. One set of vertical busbars shall be used in between two adjacent sections for switchgear connections. In case of ACB feeders, the panel shall have single front without any vertical busbar chamber, however vertical busbars associated with ACBs shall be located in rear side and shall be additionally covered with metallic perforated/ transparent acrylic or polyvinyl bolted sheets to avoid direct access after opening rear door of chamber.

(ii) Completely enclosed switchgear compartment(s) one for each circuit for housing circuit breaker or MCCB or motor starter.

(iii) A distinct compartment or alley for power and control cables on each side of panel. Cable alley compartment shall have a through metallic partition for segregating cables on both sides. Cable alley door shall preferably be hinged. Cable alley shall have no exposed live parts. Any live terminals shall be fully shrouded/insulated from safety aspects. However, it shall be of atleast 350mm width.

(iv) A compartment for relays and other control devices associated with a circuit breaker.

b) Lighting transformers shall be supplied in separate and distinct panel completely assembled for incoming cable connection from bottom and outgoing connection through busbar with adjacent associated lighting distribution board. Lighting transformers shall have provision of base channel with rollers for taking in and out from the panel in case of maintenance after disconnecting incoming and outgoing connections. Provision of single phase fans at least two (2) numbers of suitable ratings shall be made in the panel for ventilation. These fans shall run in sequential mode at suitable time interval to be controlled by thermostat and timer. The offered design of panel should be such that in no case, temperature rise of lighting transformers shall exceed the permissible limits for the class of insulation of lighting transformer.

1.1.11. Sheet steel barriers shall be provided between two adjacent vertical panels running to the full height of the switchboard, except for the horizontal busbar compartment. Each shipping section shall have full metal sheets at both ends for transport and storage.

1.1.12. All equipments associated with a single circuit except MCB circuits shall be housed in a separate compartment of the vertical section. The Compartment shall be sheet steel enclosed on all sides with the withdrawal units in position or removed. The front of the compartment shall be provided with the hinged single leaf door, with locking facilities.
In case of circuits controlled by MCBs, group of MCB feeders can be offered in common compartment. In such case number of MCB feeder to be used in a common compartment shall not exceed 4 (four) and front of MCB compartment, shall have a viewing port of toughen glass sheet for viewing and sheet steel door of module shall be lockable with star knob/panel key.

1.1.13. After isolation of power and control circuit connections it shall be possible to safely carryout maintenance in a compartment with the busbar and adjacent circuit live. Necessary shrouding arrangement shall be provided for this purpose over the cable terminations located in cable alley.

1.1.14. The minimum clearance in air between phases and between phase and earth for the entire run of horizontal and vertical busbars, shall be 25 mm. For all other components, the clearance between "two live parts", " A live part and an earthed part" and isolating distance shall be atleast ten (10) mm throughout. Wherever it is not possible to maintain these clearances, insulation shall be provided by sleeving or barriers. However, for horizontal run of busbar minimum clearance of 25 mm should be maintained even if they are sleeved.

1.1.15. The temperature rise of horizontal & vertical busbars when carrying rated current along its full run shall in no case exceed 55°C, with silver plated joints and 40°C with all other type of joints over an outside ambient temperature of 50°C.

1.1.16. All busbar chambers shall be provided with removable bolted covers . The covers shall be provided with danger labels.

1.1.17. All identical circuit breakers and module chassis of same test size shall be fully interchangeable without having to carryout modifications.

1.1.18. All Circuit breaker boards shall be of Single Front type, with fully drawout circuit breakers, which can be drawn out without having to unscrew any connections. The circuit breakers shall be mounted on rollers and guides for smooth movement between SERVICE, TEST and ISOLATED positions and for withdrawal from the Switchboard. Testing of the breaker shall be possible in the TEST position.

1.1.19. Wherever two breaker compartments are provided in the same vertical section, insulating barriers and shrouds shall be provided in the rear cable compartment to avoid accidental touch with the live parts of one circuit when working on the other circuit.

1.1.20. All disconnecting contacts for power circuits shall be of robust design and fully self aligning. Fixed and moving contacts of the power drawout contact system shall be silver plated. Both fixed and moving contacts shall be replaceable.

1.1.21. All AC & DC boards shall be of double Front type.

1.1.22. All module shall be fixed type except air circuit breaker module, which shall be drawout type.

1.1.23. The connections from busbars to the main switch shall be fully insulated/shrouded, and securely bolted. The partition between the feeder compartment and cable alley may be non-metallic and shall be of such construction as to allow cable cores with lugs to be easily inserted in the feeder compartment for termination.

1.1.24. All equipment and components shall be neatly arranged and shall be easily accessible for operation and maintenance. The internal layout of all modules shall be subject to PURCHASER approval. Bidder shall submit dimensional drawings showing complete internal details of Busbars and module components, for each type and rating for approval.

1.1.25. The tentative power and control cable entries shall be from bottom. However, Purchaser reserves the right to alter the cable entries, if required, during detailed engineering, without any additional commercial implication.

1.1.26. Adopter panels and dummy panels required to meet the various busbar arrangements and layouts required shall be included in Bidder's scope of work.

1.2. DERATING OF EQUIPMENTS

1.2.1. The current ratings of all equipments as specified in the Single Line Diagram For AC & DC System are the minimum standards current ratings at a reference ambient temperature as per relevant Indian Standards.

1.3. POWER BUS BARS AND INSULATORS

1.3.1. All AC Distribution Boards shall be provided with three phase buses and a neutral bus bars and the DC Distribution Boards shall be provided with two busbars.

1.3.2. All busbars and jumper connections shall be of high conductivity aluminium/copper of adequate size.

1.3.3. The Cross-Section of the busbars shall be uniform through out the length of Switchgear and shall be adequately supported and braced to withstand the stresses due to the specified short circuit currents.

1.3.4. All busbars shall be adequately supported by adequate numbers of high strength type Polyester fibre glass Moulded Insulators to withstand short circuit withstand capability of panel. Separate supports shall be provided for each phase and neutral busbar. If a common support is provided anti-tracking barriers shall be provided between the supports.

1.3.5. All busbars joints shall be provided with high tensile steel bolts. Belleville/spring washers and nuts, so as to ensure good contacts at the joints. Non-silver plated Busbars joints shall be thoroughly cleaned at the joint locations and a suitable contact grease shall be applied just before making a joint.

1.3.6. All busbars shall be colour coded as per IEC: 60446.

1.3.7. The Bidder shall furnish calculations, establishing the adequacy of busbar sizes for specified current ratings, On the basis of short circuit current and temperature rise consideration at specified ambient temp.

1.4. EARTH BUS

1.4.1. A galvanised steel earthing shall be provided at the bottom of each panel and shall extend throughout the length of each switchboard. It shall be welded/bolted to the frame work of each panel and breaker earthing contact bar vertical bus shall be provided in each vertical section which shall in turn be bolted/welded to main horizontal ground bus.

1.4.2. The earth bus shall have sufficient cross-section to carry the momentary short circuit and short time fault currents to earth without exceeding the allowable temperature rise.

1.4.3. Suitable arrangements shall be provided at each end of the horizontal earth bus for bolting to Purchaser's earthing conductors. The horizontal earth bus shall project out the switch-board ends and shall have predrilled holes for this connection. A joint spaced and taps to earth bus shall be made through at least two bolts.

1.4.4. All non-current metal work of the Switchboard shall be effectively bonded to the earth bus. Electrical conductivity of the whole switchgear enclosures frame work and the truck shall be maintained even after painting.

1.4.5. The truck and breaker frame shall get earthed while the truck is being inserted in the panel and positive earthing of the truck and breaker frame shall be maintained in all positions. SERVICES & ISOLATED, as well as through out the intermediate travel.

1.4.6. Air Circuit Breaker (ACB) module frame shall get engaged to the vertical earth bus, before the disconnecting contacts on these module are engaged to the vertical busbar.

1.4.7. All metallic cases of relays, instruments and other panel mounted equipments shall be connected to earth by independent stranded copper wires of size not less than 2.5 mm^2. Insulation colour code of earthing wires shall be green. Earthing wires shall be connected to terminals with suitable clamp connectors and soldering is not acceptable. Looping of earth Connection which would result in loss of earth connection to the devices when a device is removed is not acceptable. However, looping of earth connections between equipment to provide alternative paths or earth bus is acceptable.

1.4.8. VT and CT secondary neutral point earthing shall be at one place only, on the terminal block. Such earthing shall be made through links so that earthing of one secondary circuit shall be removed without disturbing the earthing of other circuit.

1.4.9. All hinged doors shall be earthed through flexible earthing braid.

1.4.10. Caution nameplate `Caution-Live Terminals' shall be provided at all points where the terminals are like to remain live and isolation is possible only at remote end.

1.5. AIR CIRCUIT BREAKERS

1.5.1. Circuit breakers shall be three-pole air break horizontal drawout type and shall have inherent fault making and breaking capacities as specified in "Technical Parameters". The circuit breakers which meet specified parameter only after provision of releases or any other devices shall not be acceptable.

1.5.2. Circuit breakers shall be mounted along with it operating mechanism on a wheeled carriage. Suitable guides shall be provided to minimise misalignment of the breaker.

1.5.3. There shall be `Service', `Test' and `Fully withdrawn positions for the breakers. In `Test' position the circuit breaker shall be capable of being tested for operation without energising the power circuits i.e. the power Contacts shall be disconnected while the Control circuits shall remain undisturbed. Locking facilities shall be provided so as to prevent movement of the circuit breaker from the `SERVICE', `TEST' OR FULLY WITHDRAWN' position. It shall be possible to close the door in TEST position.

1.5.4. All circuit breakers shall be provided with 4 NO and 4 NC potentially free auxiliary contacts. These contacts shall be in addition to those required for internal mechanism of the breaker. Separate limit switches each having required number of contacts shall be provided in both `SERVICE' & `TEST' position of the breaker. All contacts shall be rated for making continuously carrying and breaking 10 Amps at 230V AC and 1 Amp (Inductive) at 220V DC.

1.5.5. Suitable mechanical indications shall be provided on all circuit breakers to show `OPEN'. `CLOSE', `SERVICE', `TEST' and `SPRING CHARGED' positions.

1.5.6. Main poles of the circuit breakers shall operate simultaneously in such a way that the maximum difference between the instants of contacts touching during closing shall not exceed half cycle of rated frequency.

1.5.7. All circuit breakers shall be provided with the interlocks as explained in further clauses.

1.5.8. Movement of a circuit breaker between SERVICE AND TEST positions shall not be possible unless it is in OPEN position. Attempted with drawl of a closed circuit breaker shall trip the circuit breaker.

1.5.9. Closing of a circuit breaker shall not be possible unless it is in SERVICE, TEST POSITION or in FULLY WITHDRAWN POSITION.

1.5.10. Circuit breaker cubicles shall be provided with safety shutters operated automatically by the movement of the circuit breaker carriage to cover the stationary isolated contacts when the breaker is withdrawn. It shall however, be possible to open the shutters intentionally, against spring pressure for testing purpose.

1.5.11. A breaker of particular rating shall be prevented from insertion in a cubicle of a different rating.

1.5.12. Circuit breakers shall be provided with electrical anti-pumping and trip free feature, even if mechanical antipumping feature is provided.

1.5.13. Mechanical tripping shall be possible by means of front mounted RED `Trip' push-button. In case of electrically operated breakers these push buttons shall be shrouded to prevent accidental operation.

1.5.14. Breaker controlled motors shall operate satisfactorily under the following conditions:

(i) Direct on-line starting of Induction Motors rated 110 kW to 220 kW with a locked rotor current of seven times the rated current, and starting time of up to 30 seconds.

(ii) Breaking on-load, full load and locked rotor currents of Induction Motors for rated 100 kW to 220 kW.

1.5.15. Means shall be provided to slowly close the circuit breaker in withdrawn position. If required for inspection and setting of Contacts, in service position slow closing shall not be possible.

1.5.16. Power operated mechanism shall be provided with a universal motor suitable for operation 220V DC Control supply with voltage variation from 90% to 110% rated voltage. Motor insulation shall be class `E' or better.

1.5.17. The motor shall be such that it requires not more than 30 seconds for fully charging the closing spring.

1.5.18. Once the closing springs are discharged, after the one closing operation of circuit breaker, it shall automatically initiate, recharging of the spring.

1.5.19. The mechanism shall be such that as long as power is available to the motor, a continuous sequence of closing and opening operations shall be possible. After failure of power supply at least one open-close-open operation shall be possible.

1.5.20. Provision shall be made for emergency manual charging and as soon as this manual charging handle is coupled, the motor shall automatically get mechanically decoupled.

1.5.21. All circuit breakers shall be provided with closing and trip coils. The closing coils shall operate correctly at all values of Voltage between 85% to 110% at rated control voltage. The trip coil shall operate satisfactorily under all values of supply voltage between 70% to 110% of rated control voltage.

1.5.22. Provision for mechanical closing of the breaker only in `TEST' and `WITHDRAWN' positions shall be made.

1.5.23. **PROTECTION CO-ORDINATION**

1.5.23.1. It shall be the responsibility of the Contractor to fully co-ordinate the overload and short circuit tripping of the circuit breakers with the upstream and down stream circuit breakers/fuses/motor starters, to provide satisfactory discrimination.

1.6. MOULDED CASE CIRCUIT BREAKER (MCCB) and MCB

1.6.1. MCCB shall in general conform to IEC: 60947 Part-2. All MCCB offered shall have Ics = 100% Icu rating.

1.6.2. MCCB shall be flush mounted on the AC/DC distribution boards and shall have extended handle.

1.6.3 MCCBs shall be provided with thermo-magnetic type release for over current and short circuit protection. The setting of the thermal release shall be adjustable between 80% to 100% of the rated current. The MCCB shall have breaking capacity not less than 20kA.

1.6.4 MCCBs used for ACDB incomers and Bus coupler shall be equipped with stored energy mechanism for electrical closing and tripping. All other MCCBs shall be manually operated. The operating handle should give a clear trip indication.

1.6.5 Miniature circuit breaker (MCB) shall conform to IEC: 60898.

1.7 **RELAYS**

1.7.1 All relays and timers in protective circuits shall be flush mounted on panel front with connections from the inside. They shall have transparent dust tight covers removable from the front. All protective relays shall have a drawout construction for easy replacement from the front. They shall either have built-in test facilities, or shall be provided with necessary test blocks and test switches located immediately below each relay. The auxiliary relays and timers may be furnished in non-drawout cases.

1.7.2 All AC relays shall be suitable for operation, at 50 Hz with 110 volts VT secondary and 1 amp or 5 amp CT secondary.

1.7.3 All protective relays and timers shall have at least two potentially free output contacts. Relays shall have contacts as required for protection schemes. Contacts of relays and timers shall be silver faced and shall have a spring action. Adequate number of terminals shall be available on the relay cases for applicable relaying schemes.

1.7.4 All protective relays auxiliary relays and timers shall be provided with hand reset operation indicators (Flags) for analysing the cause of operation.

1.7.5 All relays shall withstand a test voltage of 2 KV (rms) for one minute.

1.7.6 Motor starters shall be provided with three element, ambient temperature compensated, time lagged, hand reset type overload relays with adjustable settings. The setting ranges shall be properly selected to suit the motor ratings. These relays shall have a separate black coloured hand reset push button mounted on compartment door and shall have at least one changeover contact.

1.7.7 All fuse-protected contactor-controlled motors shall have single phasing protection, either as a distinct feature in the overload relays (by differential movement of bimetallic strips), or as a separate device. The single phasing protection shall operate even with 80% of the set current flowing in two of the phases.

1.8 CONTACTORS

1.8.1 Motor starter contactors shall be of air break, electromagnetic type rated for uninterrupted duty as per IEC: 60947 Part 4.

1.8.2 Contactors shall be double break, non-gravity type and their main contacts shall be silver faced.

1.8.3 Direct on line starter contactors shall be of utilisation category AC2. These contactors shall be as per IEC:60947 Part 4.

1.8.4 Each contactor shall be provided with two (2) normally open (NO) and two (2) normally close (NC) auxiliary contacts.

1.8.5 Operating coils of contactors shall be of 230V AC Unless otherwise specified elsewhere. The Contactors shall operate satisfactorily between 85% to 110% of the rated voltage. The Contactor shall drop out at 70% of the rated voltage.

1.9 INSTRUMENT TRANSFORMERS

1.9.1 All current and voltage transformers shall be completely encapsulated cast resin insulated type suitable for continuous operation at the temperature prevailing inside the switchgear enclosure, when the switchboard is operating at its rated condition and the outside ambient temperature is 50°C.

1.9.2 All instrument transformers shall be able to withstand the thermal and mechanical stresses resulting from the maximum short circuit and momentary current ratings of the associated switchgear.

1.9.3 All instrument transformer shall have clear indelible polarity markings. All secondary terminals shall be wired to a separate terminal on an accessible terminal block where star-point formation and earthing shall be done.

1.9.4 Current transformers may be multi or single core type. All voltage transformers shall be single phase type. The Bus VTs shall be housed in a separate compartment.

1.9.5 All VTs shall have readily accessible MCBs on both primary and secondary sides.

1.10 INDICATING INSTRUMENTS

1.10.1 All indicating and integrating meters shall be flush mounted on panel front. The instruments shall be of at least 96 mm square size with 90 degree scales, and shall have an accuracy class of 2.5 or better. The covers and cases of instruments and meters shall provide a dust and vermin proof construction.

1.10.2 All instruments shall be compensated for temperature errors and factory calibrated to directly read the primary quantities. Means shall be provided for zero adjustment without removing or dismantling the instruments.

1.10.3 All instruments shall have white dials with black numerals and lettering. Black knife edge pointer with parallax free dials will be preferred.

1.10.4 Ammeters provided on Motor feeders shall have a compressed scale at the upper current region to cover the starting current.

1.10.5 Watt-hour meters shall be of 3 phase three element type, Maximum demand indicators need not be provided.

1.11 CONTROL & SELECTOR SWITCHES

1.11.1 Control & Selector switches shall be of rotary type with escutcheon plates clearly marked to show the function and positions. The switches shall be of sturdy construction suitable for mounting on panel front. Switches with shrouding of live parts and sealing of contacts against dust ingress shall be preferred.

1.11.2 Circuit breaker selector switches for breaker Controlled motor shall have three stay put positions marked `Switchgear', `Normal' and `Trial' respectively. They shall have two contacts of each of the three positions and shall have black shade handles.

1.11.3 Ammeter and voltmeter selector switches shall have four stayput position with adequate number of contacts for three phase 4 wire system. These shall have oval handles Ammeter selector switches shall have make before break type contacts to prevent open circuiting of CT secondaries.

1.11.4 Contacts of the switches shall be spring assisted and shall be of suitable material to give a long trouble free service.

1.11.5 The contact ratings shall be at least the following :

(i)	Make and carry continuously	10 Amp.
(ii)	Breaking current at 220V DC	1 Amp (Inductive)
(iii)	Breaking current at 230V AC	5 Amp (at 0.3 pf lagging)

1.12 **AIR BREAK SWITCHES**

1.12.1 Air breaker switch shall be of the heavy duty, single throw group operated, load break, fault make type complying with IEC: 60947 Part-3.

1.12.2 The Bidder shall ensure that all switches are adequately rated so as to be fully protected by the associated fuses during all abnormal operating conditions such as overload, locked motor, short circuit etc.

1.12.3 Switch operating handles shall be provided with padlocking facilities to lock them in `OFF' position.

1.12.4 Interlocks shall be provided such that it is possible to open the cubicle door only when the switch is in `OFF' position and to close the switch only when the door is closed. However suitable means shall be provided to intentionally defeat the interlocks explained above.

1.12.5 Switches and fuses for AC/DC control supply and heater supply wherever required shall be mounted inside and cubicles.

1.13 **PUSH BUTTONS**

1.13.1 Push-buttons shall be of spring return, push to actuate type. Their contacts shall be rated to make, continuously carry and break 10A at 230V and 0.5A (inductive) at 220V DC.

1.13.2 All push-buttons shall have one normally open and one normally closed contact, unless specified otherwise. The contact faces shall be of silver or silver alloy.

1.13.3 All push-buttons shall be provided with integral escutcheon plates marked with its function.

1.13.4 The colour of the button shall be as follows :

(i)	GREEN	:	For motor START, Breaker CLOSE
(ii)	RED	:	For motor TRIP, Breaker OPEN
(iii)	BLACK	:	For overload reset.

1.13.5 All push-buttons on panels shall be located in such a way that Red-push-buttons shall always be to the left of green push-buttons.

1.14 **INDICATING LAMPS**

1.14.1 Indicating lamps shall be of the panel mounting cluster LED type. The lamps shall have escutcheon plates marked with its function, wherever necessary.

1.14.2 Lamps shall have translucent lamp-covers of the following colours, as warranted by the application :

(i)	RED	:	For motor ON, Breaker CLOSED
(ii)	GREEN	:	For motor OFF, Breaker OPEN
(iii)	WHITE	:	For motor Auto-Trip

(iv) BLUE : For all healthy conditions (e.g. control supply, and also for 'SPRING CHARGED"

(v) AMBER : For all alarm conditions (e.g. overload) Also for `SERVICE' and `TEST' positions indicators.

1.14.3 Lamps shall be easily replaceable from the front of the cubicle.

1.14.4 Indication lamps should be located just above the associated push buttons/control switches. Red lamps shall invariable be located to the right of green lamps. In case a white lamp is also provided, it shall be placed between the red and green lamps along with the centre line of control switch/push button pair. Blue and Amber lamps should normally be located above the Red and Green lamps.

1.14.5 When associated with push-buttons, red lamps shall be directly above the green push button, and green lamps shall be directly above the red push-button. All indicating lamps shall be suitable for continuous operation at 90 to 110% of their rated voltage.

1.15 **FUSES**

1.15.1 All fuses shall be of HRC cartridge fuse link type. Screw type fuses shall not be accepted. Fuses for AC Circuits shall be of class 2 type, 20 kA (RMS) breaking current at 400 AC, and for DC circuits Class 1 type 4 kA breaking current.

1.15.2 Fuses shall have visible operation indicators.

1.15.3 Fuses shall be mounted on fuses carriers, which are mounted on fuse bases, wherever it is not possible to mount fuses on carriers fuses shall be directly mounted on plug in type of bases. In such cases one set of insulated fuse pulling handles shall be supplied with each switchgear.

1.15.4 Fuse rating shall be chosen by the Bidder depending upon the circuit requirements and these shall be subject to approval of PURCHASER.

1.16 **TERMINAL BLOCKS**

1.16.1 Terminal blocks shall be of 750 volts grade and have continuous rating to carry the maximum expected current on the terminals. It shall be complete with insulating barriers, clip-on-type/stud type terminals for Control Cables and identification strips. Marking on terminal strip shall correspond to the terminal numbering on wiring on diagrams. It shall be similar to `ELEMEX' standard type terminals, cage clamp type of Phoenix or WAGO or equivalent

1.16.2 Terminal blocks for CT and VT secondary leads shall be provided with test links and isolating facilities. CT secondary leads shall be provided with short circuiting and earthing facilities. It shall be similar to `Elem.' `CATD' - Type.

1.16.3 In all circuit breaker panels at least 10% spare terminals for external connections shall be provided and these spare terminals shall be uniformly distributed on all terminal blocks. Space for adding another 10% spare terminals shall also be available.

1.16.4 All terminal blocks shall be suitable for terminating on each side, two (2) Nos. of 2.5 mm square size standard copper conductors.

1.16.5 All terminals shall be numbered for identification and grouped according to the function. Engraved white-on-black labels shall be provided on the terminal blocks.

1.16.6 Wherever duplication of a terminal block is necessary it shall be achieved by solid bonding links.

1.16.7 Terminal blocks shall be arranged with at least 100 mm clearance between two sets of terminal block. The minimum clearance between the first row of terminal block and the associated cable gland plate shall be 250 mm.

1.17 NAME PLATES AND LABELS

1.17.1 All switchgears, AC/DC distribution boards, shall be provided with prominent, engraved identification plates. The module identification plate shall clearly give the feeder number and feeder designation. For single front switchboards, similar panel and board identification labels shall be provided at the rear also.

1.17.2 All name plates shall be of non-rusting metal or 3-ply lamicoid with white engraved lettering on black back ground. Inscriptions and lettering sizes shall be subject to PURCHASER approval.

1.17.3 Suitable plastic sticker labels shall be provided for easy identification of all equipments, located inside the panel/module. These labels shall be positioned so as to be clearly visible and shall give the device number as mentioned in the module wiring drawings.

1.18 SPACE HEATER

1.18.1 Space heater shall be provided in all the boards for preventing harmful moisture condensation.

1.18.2 The space heaters shall be suitable for continuous operation on 230V AC, 50 Hz, single phase supply, and shall be automatically controlled by thermostats. Necessary isolating switches and fuses shall also be provided.

1.19 CONTROL AND SECONDARY WIRING

1.19.1 All switchboards shall be supplied completely wired internally upto the terminal blocks ready to receive Purchaser's control cables.

1.19.2 All inter cubicle and inter panel wiring and connections between panels of same switchboard including all bus wiring for AC and DC supplies shall be provided by the bidder.

1.19.3 All internal wiring shall be carried out with 1100 V grade, single core, 1.5 square mm or larger stranded copper wires having colour coded, PVC insulation. CT circuits shall be wired with 2.5 square mm copper wires. Voltage grade and insulation shall be same as above.

1.19.4 Extra-flexible wires shall be used for wiring to device mounted on moving parts such as hinged doors.

1.19.5 All wiring shall be properly supported, neatly arranged, readily accessible and securely connected to equipment terminals and terminals blocks.

1.20 POWER CABLES TERMINATION

1.20.1 Cable termination compartment and arrangement for power cables shall be suitable for stranded aluminium conductor, armoured XLPE/PVC insulated and sheathed, single core/three core, 1100 V grade cables.

1.20.2 All necessary cable terminating accessories such as Gland plates, supporting clamps and brackets, power cable lugs, hardware etc. shall be provided by the successful bidder, to suit the final cable sizes which would be advised later.

1.20.3 The gland plate shall be of removable type and shall cover the entire cable alley. Bidder shall also ensure that sufficient space is provided for all cable glands. For all single core cables, gland plates shall be of non-magnetic Material.

1.21 TYPE TESTS

1.21.1 Type tests reports on Panels (Switchgear and Control gear assemblies) as per IEC: 60439 Part-1 shall be submitted for the following tests in line with clause 9.0 of Chapter 2 GTR before the fabrication of switchgear is started:

i) Verification of temperature rise limits
ii) Verification of the dielectric properties
iii) Verification of short circuit strength
iv) Verification of the continuity of the protective circuit
v) Verification of clearances and creepage distances
vi) Verification of mechanical operation
vii) Verification of degree of protection

1.21.2 Contractor shall submit type test reports for the following Switchgear and Control gears before the fabrication of switchgear is started:

1. Circuit breakers/MCCB as per IEC: 60947 Part 2.
2. Protective Relays as per IEC: 60255.
3. Lighting transformers as per IEC:60076

For above equipments, test conducted once are acceptable (i.e. The requirement of test conducted within last five years shall not be applicable)

1.22 ERECTION, TESTING AND COMMISSIONING

1.22.1 The Contractor shall unload, erect, install, test and put into commercial use all electrical equipment included in this specification.

1.22.2 Equipment shall be installed in a neat, workman like manner so that it is level, plumb, square and properly aligned and oriented. Tolerance shall be as established in Contractor's drawings or as stipulated by purchaser. No equipment shall be permanently bolted down to foundations until the alignment has been checked and found acceptable by the purchaser.

1.22.3 Contractor shall furnish all supervision, labour tools equipment rigging materials, bolts, wedges, anchors, concrete inserts etc. in proper time required to completely install, test and commission the equipment.

1.22.4 Manufacturer's and purchaser's instructions and recommendations shall be correctly followed in handling, setting, testing and commissioning of all equipment.

1.22.5 Contractor shall move all equipment into the respective room through the regular door or openings specifically provided for this purpose. No part of the structure shall be utilised to lift or erect any equipment without prior permission of Purchaser.

1.22.6 All boards shall be installed in accordance with relevant code of practices and at Purchaser's instructions. All boards shall be installed on finished surfaces, concrete or steel stills. Contractor shall be required to install and align any channel sills which form part of foundations. In joining shipping sections of switchboards together adjacent housing of panel sections or flanged throat sections shall be bolted together after alignment has been completed. Power bus, enclosures ground and control splices of conventional nature shall be cleaned and bolted together being drawn up with torque spanner of proper size or by other approved means.

1.22.7 All boards shall be made completely vermin proof.

1.22.8 Contractor shall take utmost care in holding instruments, relaying and other delicate mechanism wherever the instruments and relays are supplied separately they shall be mentioned only after the associated panels have been erected and aligned. The packing materials employed for safe transit of instrument and relays shall be removed after ensuring that panel have been completely installed and to further movement of the same should be necessary. Any damage shall be immediately reported to Purchaser.

1.22.9 Equipment furnished with finished coats of paint shall be touched by up Contractor if their surface is specified or marred while handling.

1.22.10 After installation of panels, power and control wiring and connections, Contractor shall perform operational tests on all switchboards, to verify proper operation of switch-boards/panels and correctness of all equipment in each and every respect. The cable opening and cables entries for cables terminating to the panels shall be sealed with fire sealing materials.

1.23 COMMISSIONING CHECK TESTS

The Contractor shall carry out the following commissioning checks, in addition to the other checks and tests recommended by the manufacturers.

1.23.1 General

1.23.1.1 Check name plate details according to the specification.

1.23.1.2 Check for physical damage.

1.23.1.3 Check tightness of all bolts, clamps, joints connecting terminals.

1.23.1.4 Check earth connection.

1.23.1.5 Check cleanliness of insulators and bushings.

1.23.1.6 Check all moving parts for proper lubrication.

1.23.1.7 Check settings of all the relays.

1.23.2 **Circuit Breakers**

1.23.2.1 Check alignment of breaker truck for free movement.

1.23.2.2 Check correct operation of shutters.

1.23.2.3 Check control wiring for correctness of connections, continuity and IR values.

1.23.2.4 Manual operation of breaker completely assembled.

1.23.2.5 Power closing/opening operation, manually and electrically.

1.23.2.6 Breaker closing and tripping time.

1.23.2.7 Trip free and anti-pumping operation.

1.23.2.8 IR values, minimum pick up voltage and resistance of coils.

1.23.2.9 Contact resistance

1.23.2.10 Simultaneous closing of all the three phases.

1.23.2.11 Check electrical & mechanical interlocks provided.

1.23.2.12 Check on spring charging motor, correct operation of limit switches, and time of charging.

1.23.2.13 All functional checks.

1.23.3 **Current Transformers**

1.23.3.1 Megger between winding and winding terminals to body.

1.23.3.2 Polarity test

1.23.3.3 Ratio identification checking of all ratios on all cores by primary injection of current.

1.23.3.4 Spare CT cores, if available, to be shorted and earthed.

1.23.4 **Voltage Transformer**

1.23.4.1 Insulation resistance test

1.23.4.2 Ratio test on all cores.

1.23.4.3 Polarity test.

1.23.4.4 Line connections as per connection diagram.

1.23.5 **Cubicle Wiring**

1.23.5.1 Check all switch developments.

1.23.5.2 Each wire shall be traced by continuity tests and it should be made sure that the wiring is as per relevant drawing. All interconnections between panels/equipment shall be similarly checked.

1.23.5.3 All the wires shall be meggered to earth.

1.23.5.4 Functional checking of all control circuit e.g. closing, tripping control, interlock, supervision and alarm circuit.

1.23.6 **Relays**

1.23.6.1 Check connections and wiring.

1.23.6.2 Megger all terminals to body.

1.23.6.3 Megger AC to DC terminals.

1.23.6.4 Check operating characteristics by secondary injection.

1.23.6.5 Check minimum pick up voltage of DC coils.

1.23.6.6 Check operation of electrical/mechanical targets.

1.23.6.7 Relays settings.

1.23.6.8 Check CT and VT connections with particular reference to their polarities for directional relays, wherever required.

1.23.7 **Meters**

1.23.7.1 Check calibration by comparing it with a sub-standard.

1.23.7.2 Megger all insulated portions.

1.23.7.3 Check CT and VT connections with particular reference to their polarities for power type meters.

1.24 **SPECIAL TOOLS AND TACKLES**

1.24.1 The Bidder shall include in his proposal any special tools and tackles required for erection, testing commissioning and maintenance of the equipments offered.

1.24.2 The list of these special tools and tackles shall be given in the bid proposal sheets alongwith their respective prices.

1.24.3 The total price of the special tools and tackles shall be included in proposal sheets.

1.25 EQUIPMENT TO BE FURNISHED

1.25.1 The Bidder shall quote for various AC/DC distribution boards in accordance with this specification.

1.25.2 Standard scheme of interconnection of switchboards and distribution boards alongwith tentative feeder disposition for each board is indicated in Standard SLD of AC & DC system enclosed alongwith bid documents. The bidder shall quote board prices on the basis of standard SLD and their estimation of feeders for entire present and future bays requirement. Any other feeder required as per system requirement for efficient and reliable operation shall be deemed to be included in bidder's scope.

1.25.3 The Bill of Materials for each type of module shall be as under. These are minimum indicative requirement of the system. The necessary auxiliary relays, push buttons and indicating lamps shall be provided as per scheme requirement. Any other item/component required with in a module for efficient and reliable operation shall be deemed to be included in bidder's scope.

1.25.4 Module Type AE (Electrically controlled circuit breaker for incoming and Bus Coupler Circuit).

(i)	One (1)	Triple pole air circuit breaker complete with all accessories and power operated mechanism as specified.
(ii)	Two (2)	Neutral link.
(iii)	Three (3)	Current Transformer for metering.
(iv)	One (1)	Ammeter with selector switch.
(v)	Three (3)	Current Transformer for relaying.
(vi)	One (1)	Triple pole instantaneous over-current relay having the setting range of 200-800% or 500-2000% of CT secondary and adjustable definite minimum time.
(vii)	One (1)	Instantaneous earth fault relay having an adjustable setting range of 10-40% or 20 - 80% of CT secondary current and adjustable definite minimum time. The earth fault relay shall be provided with a stabilising resistor.
(viii)	One(1) set	Current and Voltage transducers.
(ix)	One(1) set	High speed tripping relays.

1.25.5 **Module Type - M1 (Circuit Breaker Controlled Motor Feeder)**

(i)	One (1)	Triple pole Air Circuit Breaker complete with accessories, and power operated mechanism as specified.
(ii)	One (1)	Three position 6 pole selector switch 'SWITCHGEAR/NORMAL /TRIAL'.
(iii)	Three (3)	Current Transformer for metering.

(iv)	One (1)	Ammeter with Ammeter Selector Switch
(v)	Three (3)	Current Transformer for relaying.
(vi)	One (1)	Triple pole instantaneous over-current relay for providing positive sequence current protection in all the three phases. The relay setting range shall be continuously adjustable between 200-800% or 400-1600% of CT secondary rated current as required.
(vii)	One (1)	Double pole inverse definite minimum time over current relays connected in R & B phases for over current protection of motor rated 110 kW - 200 kW. The relay shall have an adjustable setting range of 50% - 200% of CT Secondary current and time setting range of 0-30 Second. The relay shall be CDGM-22 of EE or equivalent.
(viii)	One (1)	Single pole adjustable definite time delay relay for motor overload alarm connected in Y-phase only. The relay shall have resetting ratio of not less than 90%. The relay shall have continuously adjustable time delay range of 2.5 to 25 Sec.
(ix)	One (1)	Instantaneous earth fault relay having an adjustable setting range of 10-40% or 20-80% of CT secondary current. The earth fault relay shall be provided with a stabilising resistor.
(x)	One(1) set	Current and Voltage transducers.
(xi)	One(1) set	High speed tripping relay.

1.25.6 **Module Type E**

(i)	One (1)	Four pole MCCB

1.25.7 **Module G-1 (VT Module with under Voltage Relay)**

(i)	Three (3)	$\frac{400}{\sqrt{3}} / \frac{110}{\sqrt{3}}$ volts single phase voltage transformer star/star connect with star point solidly earthed mounted on common draw out chassis. Accuracy Class 0.5 for protection and metering with 50VA Burden.
(ii)	Six (6)	HRC Fuses mounted on the above chassis.
(iii)	One (1)	Four position voltmeter selector switch.
(iv)	One (1)	Voltmeter (0-500V)
(v)	One (1)	Double pole instantaneous under voltage relays with continuous variable setting range of 40-80% of 110 Volts.

(vi)	One (1)	Time delay pick up relay having a time setting range of 0.5 to 3 secs. with 3 `NO'. Self reset contacts, suitable for 220V DC.
(vii)	One (1)	Auxiliary relay 220V DC with 2 NO. self reset contacts.
(viii)	Three (3)	Indicating lamps with series resistor and colour lenses (Red, Blue & Yellow).

1.25.8 **Module Type G-2**

(i)	Three (3)	HRC Fuse
(ii)	One (1)	Voltmeter (0-500V)
(iii)	One (1)	Voltmeter selector switch four position (R-Y, Y-B, B-R OFF).
(iv)	Three (3)	Indication lamps (Red, Blue & Yellow)

1.25.9 **Module Type H & H (BC) (Isolating Switch Controlled Incoming Circuit)**

(i)	One (1)	Four pole MCCB
(ii)	One (1)	Red Indicating lamp to indicate isolating switch closed position.

1.25.10 **Module Type S : (DC Metering and Protection Module)**

(i)	One (1)	Voltmeter 300-0-300V DC for 220V DC DB/Voltmeter 0-75V DC for 50V DCDB
(ii)	One (1)	Three (3) position voltmeter selector switch
(iii)	One (1)	Instantaneous under voltage relay with 95% of 220V DC. The resetting ratio of relay of relay should not be more than 1.25. The relay shall be provided with a series resistor and a push button across if for resetting (pick up) the relay at about 105% of the drop out voltage.
(iv)	One (1)	Instantaneous over voltage relay with setting range of 110% of 220V DC. The resetting ratio of relay should not be less than 0.8. The relay shall have a push button in series of resetting the relay at about 95% of the operating voltage.
(v)	One (1)	Earth leakage relay only for 220V DC system having adjustable pick up range between 3 to 7 milliamps the relay shall be suitable for 220V DC/230V AC Auxiliary supply.

1.25.11 **Module Type X**

One (1) Double pole 250 V MCB

1.25.12 **Module Type-DC (Incomer from Battery & Chargers)**

(i) One (1) Double pole 250V DC MCCB for incomer from Battery.

(ii) One (1) DC ammeter with shunt and range of 90-0-400 Amps. For 220V DC DB and 90-0-200 Amp for 50V DC DB.

(iii) Two (2) Double pole 250V DC MCCB/MCB

(iv) One (1) Double pole single throw 250V DC air break switch connecting battery & charger sections to DC DB.

(v) One(1) set Voltage and Current Transducers

1.25.13 **Module Type DG-1 (Electrically Controlled Circuit Breaker for Incomer from DG Set)**

a) One (1) Triple pole circuit breaker complete with all accessories and power operated mechanism as specified.

b) One (1) Frequency meter.

c) One (1) Voltmeter with selector switch.

d) One (1) Remote/Local Selector switch.

e) Three (3) Current transformer for metering.

f) Six (6) Current Transformers for differential protection (out of this 3 Nos. will be supplied loose for mounting in DG set panel).

g) Three (3) Current transformer for relaying.

h) One (1) Ammeter Selector Switch.

i) One (1) Ammeter

j) One (1) Wattmeter of range 0-300 KW.

k) One (1) Three pole voltage controlled definite time delay relay having current setting range of 50-200% of CT secondary current and adjustable time delay 0.3 to 3 secs.

l) One (1) Watt hour meter with six (6) digits and minimum count of one (1) kwh.

m) One (1) Single pole definite time over current relay having a continuous setting range of 50-200% of CT secondary current and a time delay of 2.5-25 secs connected in CT of Y phase for overload alarm. The relay shall have a setting ratio of not less than 90%.

n) One (1) Three pole differential protection relay having an operating current setting range of 10-40% of generator full load current. The relay shall be of high impedance type, with necessary stabilizing resistors.

o) Two (2) Push buttons for Remote starting & stopping of DG Set (Red, Green).

p) One(1) set Current and Voltage transducers.

q) One(1) set High speed tripping relays.

1.25.14 **Module Type H1**

One (1) Double pole DC Switch with pad locking facility in off position.

1.25.15 **Module Type EL**

(i) One (1) Four pole MCCB

(ii) One (1) Contactor

(iii) Electronic Timer suitable for continuous operation, push button and selector switch be as per scheme requirement

1.26 **PARAMETERS**

1.26.1 **Power Supply**

1.26.1.1 AC System 3 phase, 4 wire, solidly earthed

a) Voltage 400 Volts, ± 10%

b) Frequency 50 Hz ± 2.5%

c) Combined variation ± 105% Absolute Sum in Voltage & frequency

d) Fault Level 20 kA (rms)

1.26.1.2 **DC System** 2 Wire, unearthed

a) System voltage 220V ± 10%

b) Fault Level 4 kA

c) System Voltage 48 V ± 10%

d) Fault Level --

1.26.2 **Control Supply Voltage**

a)	Trip and closing coils	220V DC Unearthed
b)	Spring charging	220V DC Unearthed

1.26.3 **Cubicle Data**

1.26.3.1 **Busbar Rating**

a)	Continuous for Vertical panels.	As specified in Standard SLD For AC & DC system.
b)	Short time (1 sec. kA (rms)	20 kA
c)	Momentary (kA) PEAK	45 kA
d)	Ambient Temperature	50°C
e)	One Minute Power Frequency Withstand	
	I. Power Circuit	2500 Volts (rms)
	II. Control Circuit	2500 Volts (rms)

1.26.3.2 **Cubicle Colour Finish**

a)	Interior	Smoke Grey shade No.692
b)	Exterior	Smoke Grey shade No.692

1.26.4 **Circuit Breaker**

a)	Type	Air Break
b)	No. of poles	3
c)	Voltage & Frequency	400 Volts, ± 10%, 50 HZ + 2.5%
d)	Rated Operating Duty	As per IEC
e)	Rated service short-circuit Breaking capacity (Ics)	20 kA (RMS)
f)	Short Circuit making current	45 kA (Peak)
g)	Short time withstand current for 1 sec. duration.	20 kA (RMS) for 1 sec.

h)	Operating Mechanism current for 1 sec. duration.	20 kA (RMS) for 1 sec.
i)	No. of auxiliary contacts	4 NO & 4 NC contacts for Purchaser's use on fixed portion of the cubicle
j)	Short Circuit breaking current	
	I. AC Component	20 kA (RMS)
	II. DC Component	As per IEC: 60947 (Part 2)

1.26.5 **MOULDED CASE CIRCUIT BREAKER**

		AC System	DC System
a)	No. of poles	4	2
b)	Voltage & Frequency	400 Volts, ± 10% 50 HZ ± 2.5%	250V
c)	Rated Operating Duty	As per IEC	
d)	Rated service short-circuit Breaking capacity (Ics)	20 kA (RMS)	4 kA
e)	Short Circuit making current	45 kA (Peak)	-
f)	No. of auxiliary Contacts (only for incomer And bus-coupler MCCBs)	1 NO &1 NC	1 NO &1 NC
g)	Rated Ultimate Short Circuit breaking capacity		
	I. AC Component	20 kA (RMS)	As per IEC
	II. DC Component	As per IEC 60947	As per IEC 60947

1.26.6 **Meters**

a)	Accuracy class	2.5
b)	One minute power frequency withstand test voltage in KV	2.0

1.26.7 **Current Transformers**

a)	Type	Cast resin, Bar primary

b)	Voltage class and frequency	650V, 50 Hz
c)	Class of Insulation	E or better
d)	Accuracy class metering CT	Class 1, VA adequate for application but not less than 7.5 VA.
e)	Accuracy class protection CT	5 P 15, VA adequate for application, but not less than 7.5 VA.
f)	Accuracy class differential protection	PS, KPV = 300V
g)	Short Time Current Rating (for CTs Associated with circuit breakers)	

I.	Current	20 kA (RMS)
II.	Duration	One Second
III.	Dynamic Rating	45 kA (Peak)
IV.	One minute power frequency withstand test voltage.	2.5 kV (rms)

1.26.8 **Voltage Transformer**

a)	Type	Cast Resin
b)	Rated Voltage	
	Primary	400/√3 V
	Secondary	110/√3 V
c)	Method of connection	
	Primary	Star
	Secondary	Star
d)	Rated voltage factor	1.1 continuous, 1.5 for 3 seconds
e)	Class of insulation	E or better
f)	One minute power frequency withstand voltage	2.5 KV (RMS)

g) Accuracy class 0.5, not less than 20VA

1.26.9 **Relay**

a) One minute power Frequency withstand test 2 kV (rms)

1.26.10	**Transducers (1 phase)**	**Current**	**Voltage**
	a) Operating Voltage	220 V DC	220V DC
	b) I/P	1A.	110V AC
	c) O/P	4-20 mA	4-20 mA
	d) Type	Analogue	Analogue

1.26.11 **Lighting Transformers**

Lighting transformers shall be of 100 KVA rating, 400/4400 V, 3 phase, 50 Hz Dry type natural air cooled type. The technical parameters of these lighting transformers are as follows:

Technical Parameters of Lighting Transformer

Type of transformer	:	Dry type natural air cooled
Rating	:	100 KVA
Voltage ratio	:	400/400 volts
No. of phases	:	Three
Frequency	:	50 Hz
Winding connection	:	Dyn-1
Class of insulation	:	'B' class
Impedance	:	4% ± 10%
No. of taps & steps	:	5, ± 5% in steps of 2.5%
Ref. standard	:	IEC: 60076

1.27 **AUTOMATIC CONTROL OF OUTDOOR LIGHTING**

1.27.1 EL-type module of 400V Main lighting distribution board and Emergency lighting distribution board and shall be controlled by timer and contactor module to facilitate its operation automatically.

1.28 AUTOMATIC SUPPLY CHANGEOVER

Automatic changeover between Incomer I, Incomer II, and DG set is to be carried out during the failure of supply in one/or both the incomers. After the restoration of the supply, system shall be restored to normal condition automatically. The requirement of changeover under various conditions are as below:

(i) Under normal conditions i.e. when supply is available in both the incomers, incomers I&II of 400 V Main switchboard, ACDB shall be in closed condition and Bus couplers and DG set breaker shall be in open condition.

(ii) In case of failure of either of the sources, the incomer of that source shall trip and Bus coupler shall get closed. On restoration of supply, normal conditions described above are to be established automatically.

iii) In case of failure of supply in both the sources, both incomers, incomers of ACDBs and ACDB Bus coupler shall trip and DG set breaker switched on.
On restoration of one or both sources, DG set breaker shall trip, DG set stopped and conditions described in paragraph (i) /(ii) shall be restored.

To avoid unnecessary operation of switchgear for momentary disturbances all changeovers from one state to another shall be initiated after a time delay, after the conditions warranting such change has been detected.

1.29 ANALOGUE INPUTS

LT System shall have provision of following analogue inputs for owner's substation automation purpose. These analogue inputs shall be generated by distinct transducers to be provided in respective modules. These inputs shall be wired up to respective terminal blocks.

ANALOGUE INPUTS:

i) Voltage R-Y, Y-B, B-R of Main Switch Board section-I
ii) Voltage R-Y, Y-B, B-R of Main Switch Board section-II
iii) Current from LT transformer-I
iv) Current from LT transformer-II
v) Voltage of 220V DCDB-I
vi) Voltage of 220V DCDB-II
vii) Current from 220V Battery set-I
viii) Current from 220V Battery set-II
ix) Voltage of 48V DCDB-I
x) Voltage of 48V DCDB-II
xi) Current from 48V Battery set-I
xii) Current from 48V Battery set-II

1.30 DIGITAL (Potential Free) INPUTS:

LT System shall have provision of following digital inputs for owner's substation automation purpose. These digital inputs shall be made available in the form of potential free contacts to be provided in respective modules. These potential free contacts shall be wired up to respective terminal blocks.

i) Main (MSB) Incomer-I breaker On/Off

ii) Main (MSB) Incomer-II breaker On/Off
iii) Main(MSB) 400V Bus-I/II U/V
iv) Main (MSB) bus coupler breaker on/off
v) DG set breaker on/off
vi) LT transformer-I Bunchholz Alarm & trip
vii) LT transformer-II Buchloz Alarm & trip
viii) LT transformer-I WTI Alarm & trip
ix) LT transformer-II WTI Alarm & trip
x) LT transformer-I OTI Alarm & trip
xi) LT transformer-II OTI Alarm & trip
xii) 220 V DC-I earth fault
xiii) 220V DC-II earth fault

CHAPTER 8: LT TRANSFORMER

1.0 INTENT

This specification is intended to cover outdoor type oil filled 33/0.400KV, 630 kVA transformers.

2.0 SCOPE OF WORK

2.1 Scope of Supply

- Transformers as listed above, with insulating oil, all materials and accessories, and complete in all respects.
- Gland plates, power cable, lugs, anchor bolts and hardwares.
- Mandatory & optional spares and special maintenance equipments if any.

2.2 Scope of Service

The scope includes but is not limited to the following items of work to be performed for all equipment and materials furnished under this chapter:

a) Design, manufacturing, shop testing, packing & despatch
b) Transportation inclusive of insurance and delivery, FOR site basis
c) Unloading, handling, storing, transportation at site up to foundations, oil filling and treatment, erection, testing and commissioning
d) Civil Works
e) Supply of external cables and termination as required.
f) Fire protection system.

3.0 GENERAL INFORMATION

3.1 All temperature indicators, Buchholz relays and other auxiliary devices shall be suitable for 220 V DC Control supply. All alarm and trip Contacts shall also be suitable for connection in 220V DC Circuits.

3.2 Bidders may specifically note that transformers offered shall conform to dynamic short circuit test and dielectric test as per IEC: 60076. Test report for the same shall be submitted during detail engineering for approval.

4.0 TECHNICAL REQUIREMENTS

4.1 Core

The core shall be constructed from high grade, non-aging, cold rolled grain-oriented silicon steel laminations. The maximum flux density in any part of the cores and yoke at normal voltage and frequency shall be such that the flux density at any tap position with 10% voltage variation from the voltage corresponding to the tap shall not exceed 1.9 Wb/sq-m.

4.2 **Windings**

The conductor shall be of electrolytic copper, free from scales and burrs.

4.3 **Insulating Oil**

The oil supplied with transformer shall be unused and have the parameters for unused new oil conforming to IEC: 60296 while tested at oil Contractor's premises, No inhibitors shall be used in oil. Ten percent extra oil shall be supplied for topping up after commissioning in nonreturnable containers suitable for outdoor storage.

4.4 **Terminal Arrangement**

a) Bushing terminals shall be provided with suitable terminal connectors of approved type and size for cable/overhead conductors termination of HV side and cable termination on LV side.

b) The neutral terminals of 400V winding shall be brought out on a bushing along with the 433 volt phase terminals to form a 4 wire system for the 400 volt. Additional neutral bushing shall also be provided for earthing.

4.5 **Off Circuit Tap Changing Equipment**

The tap change switch shall be three phase, hand operated for simultaneous switching of similar taps on the three phases by operating an external hand wheel.

4.6 **Marshalling Box**

A metal enclosed, weather, vermin & dust proof marshalling box shall be provided with each transformer to accommodate temperature indicators, terminal blocks etc. It shall have a degree of protection of IP 55 as per IEC: 60947 Part-1.

4.7 **Cable boxes**

Whenever cable connections are required, suitable cable boxes shall be provided and shall be air insulated. They shall be of sufficient size to accommodate Purchaser's cables and shall have suitable removable side/top cover to facilitate cable termination and inspection. Cable boxes shall be dust & vermin proof.

5.0 INSPECTION AND TESTING

a) The Contractor shall draw up and carry out a comprehensive inspection and testing program during manufacture and commissioning of the transformer. The programme shall be duly approved by the Purchaser.

b) The Contractor shall carryout all routine tests on all the transformers as per relevant standards. Type test report shall be submitted for approval during detail engineering.

6.0 INSPECTION

6.1 Tank and Accessories

a) Physical and dimensional check of transformer tank and accessories.

b) Crack detection of major strength weld seams by dye penetration test.

6.2 Core

a) Physical inspection and check of quality of varnish, if used.
b) Sample testing of core material for checking specific loss, bend properties, magnestisation, characteristics and thickness.
c) Check on completed core for measurement of iron loss and check for any hot spot by exciting the core so as to induce the designed value of flux density in the core.
d) HV Test

6.3 Insulating Material

a) Sample checks for physical properties of the material

b) Check for dielectric strength

c) Check for the reaction of hot oil on insulating material

6.4 Winding

a) Sample check on winding conductor for mechanical properties and electrical conductivity and on installation covering.

b) Sample check on insulation paper for pH value, Bursting strength, Electric strength.

6.5 **Assembled Transformer**

a) Check complete transformer against approved outline drawing provision for all fittings, finish etc.

b) Jacking test on all the assembled transformers.

6.6 **Oil**

All Standard tests in accordance with relevant Standards shall be carried out on oil samples taken from the transformer before and after testing of the transformer.

The contractor shall also prepare a comprehensive inspection and testing programme for all bought out sub-contracted items and shall submit the same to the Purchaser for approval. Such programme shall include the following components:

a) Buchholz Relay
b) Winding temperature Indicator
c) Bushings
d) Marshaling Box
e) Tap changer switch
f) Oil temperature indicator

7.0 FACTORY TEST

7.1 All standard routine tests in accordance with latest issue of IEC: 60076 shall be carried out on each transformer.

7.2 The transformer shall conform to all the type tests in accordance with latest issues of IEC: 60076. The manufacturer shall submit type tests & additional test reports as listed above as already carried out on transformers of identical design for owner's acceptance. In such a case validity of type test reports shall be in line with clause 9.2 of Chapter 2-GTR of technical specifications. Following parameters in general shall be ensured for establishment of identical design as per IEC 60076, Part-V.

a) Same Voltage ratio, KVA rating, vector group & impedance.
b) Same conceptual design of core and winding.
c) Same arrangement and geometrical sequence of the main windings.
d) Same type of winding conductors.
e) Same type of main windings.
f) Absorbed power at short circuit (ie rated power/per unit short circuit impedance) between 30% and 130% of that relating to the reference transformer.

g) Axial forces and winding stresses occurring at short circuit not exceeding 120% of those relating to the reference transformer.
h) Same manufacturing process.
i) Same Clamping and winding support arrangement..

7.3 In addition to all type and routine tests, transformer shall also conform to following additional type tests as per IEC: 60076.

a) Measurement of zero sequence impedance

b) Short circuit test

c) Measurement of acoustic noise level. This shall conform to NEMA standard publication TR-1.

d) Measurement of capacitance and tan delta of transformer winding.

e) Test on oil samples as per equivalent international standard.

7.4 All auxiliary equipment shall be tested as per the relevant Test Certificates shall be submitted for bought out items.

7.5 High voltage withstand test shall be performed on auxiliary equipment and wiring after complete assembly.

7.6 Tank Tests:
i) Routine Tests: As per IEC: 60076 Part-1 including
ii) Vacuum Tests: As per IEC: 60076 Part-1
iii) Pressure Test: As per IEC: 60076 Part-1

7.7 In addition to the above, the following checks should be carried out at manufacturer's works before despatch for all transformers:

a) Check for interchangeability of components of similar transformers and for mounting dimensions.

b) Check for proper packing and preservation of accessories like radiators, bushings explosion vent, dehydrating breather, Buchholz relay, conservator etc.

c) Check for proper provision of bracings to arrest the movements of core and winding assembly inside the tank.

d) Test for gas tightness and derivation of leakage rate. To ensure adequate reserve gas capacity during transit and storage.

7.8 The Contractor shall submit a detailed inspection and testing programme for field activities, covering areas right from the receipt of material stage upto commissioning stage as per equivalent international standard - Code of practice for installation and maintenance of transformers. The indicative checks and tests are given below.

a) Physical checks on each transformer on receipt at site for any damage or short supply.
b) Tests on oil samples
c) Oil leakage test
d) Physical checks for colour of silica in breather
e) Check for oil level in breather housing, conservator tank, etc.
f) Check for correct operation of all protections and alarms.
g) Insulation Resistance Measurement for Main Winding, control wiring etc.
h) Continuously observe the transformer operation at no load for 24 hours.

8.0 FITTINGS

The following fittings shall be provided with each transformer covered under this specification.

i) Conservator with drain plug and oil filling hole with blanking plate
ii) Plain oil Gauge
iii) Silica gel Breather
iv) Pressure Relief vent
v) Pocket on tank cover for Thermometer
vi) Valves
vii) Earthing Terminals
viii) Rating & Terminal Marking Plates
ix) Lifting Lugs
x) Rollers
xi) Air Release Plug

The fittings listed above are only indicative and any other fittings which generally are required for satisfactory operation of transformer are deemed to be included.

9.0 SPARE PARTS

9.1 The list of spares for outdoor type transformers covered under this chapter shall be as specified in Chapter 1- PSR

9.2 In addition, the Bidder shall also recommend optional spare parts and maintenance equipment necessary for three (3) years of successful operation of the equipment. The prices of these shall be indicated in respective schedules and these shall not be considered for the purpose of evaluation.

10.0 TECHNICAL SPECIFICATION

10.1 630KVA, 33/0.4 kV

S.N.	Description	Unit	Parameters
1	Rated Capacity	kVA	630
2	Rated Voltage		
a)	HV	kV	33
b)	LV	kV	0.400
3	Type of Winding		Two Winding
4	Service		Outdoor
5	No of Phases	No.	Three
6	Frequency	Hz	50
7	Type of Cooling		ONAN
8	Impedance at 75 Deg C	%	0.05
9	Tolerance on Impedance	%	±10
10	Duty		Continuous
11	Overload		IEC:60076-7
12	Max. Temp. Rise over an ambient of 50 Deg C		
a)	Oil (Temperature rise measurement by thermometer)	^{O}C	50
b)	Winding Temperature rise measurement by resistance method)	^{O}C	55
13	Windings		
a)	System Apparent Short circuit level (kA)		As per IEC: 60076-Part 1
b)	Winding Connection		

S.N.	Description	Unit	Parameters
(i)	HV		Delta
(ii)	LV		Star
14	Vector Group		Dyn1
15	Insulation		Uniform
16	Insulation Level	kVrms	
a)	Power Frequency Test Level		
(i)	HV	kVrms	95
(ii)	LV	kVrms	2
17	Basic Impulse Level		
(i)	HV	kVp	250
(ii)	LV	kVp	-
18	Highest voltage (kV) for each winding	kV	52
19	Method of earthing		Solidly earthed
20	Tap changer		
a)	(i) Tap Change		+5% to -10% in step of 2.5% on HV side
b)	(ii) Tap control		Off Circuit Tap Change Switch
21	HV Bushing		
a)	Rated Voltage	kV	52
b)	Rated current	A	100
c)	Basic Impulse Level (kVp)	kVp	250
d)	Wet & Dry Power frequency Withstand Voltage	kVrms	95
e)	Min. Total Creepage Distance	mm	1300
f)	Mounting		Tank / Transformer Body
22	LV & Neutral Bushing		

S.N.	Description	Unit	Parameters
a)	Rated Voltage	kV	1.1
b)	Rated current	A	1000
c)	Basic Impulse Level (kVp)	kVp	-
d)	Wet & Dry Power frequency Withstand Voltage	kVrms	2
e)	Mounting		Tank / Transformer Body
23	Terminal Details		
a)	HV		Suitable for 33kV Cable or Over Head Conductor
b)	LV & Neutral		Cable Box
24	Min. Clearance in Air	mm	
a)	Ph-Ph (HV/LV)	mm	530/25
b)	Ph-Earth (HV/LV)	mm	480/25

CHAPTER 9: LIGHTING SYSTEM

1.0 LIGHTING SYSTEM

1.1 *LIGHTING SYSTEM FOR SUBSTATION*

The scope of work comprises of design, engineering, testing, supply, installation, testing and commissioning of various lighting fixtures complete with lamps, supports and accessories, ceiling fans complete with electronic regulators, exhaust fans for toilets and pantry & accessories, lighting panels, lighting poles complete with distribution boxes, galvanized rigid steel /rigid PVC conduits, lighting wires, G.I. Earthwire, receptacles, tag block & telephone socket, switchboards, switches, junction boxes, pull out boxes complete with accessories, for control room cum administrative building, Township, Indoor Switchgear room, Fire Fighting pump house, Switchyard and street lighting, GIS Building.

The entire control room building, fire fighting pump house,, Indoor Switchyard Building lighting shall be done by LED based low power consumption luminaries to achieve desired lux level specified. The bidder shall quote on lumpsum basis on the basis of design criteria specified for each control room building and fire fighting pump house.

1.1.1 SYSTEM DESCRIPTION

The lighting system shall comprise of the following:

1.1.2 AC Normal Lighting

AC lights will be connected to AC lighting panels. All the lights connected to the AC lighting system in different areas will be connected to the main lighting distribution boards.

1.1.3 AC Emergency Lighting

This system will be available in control room building, Fire fighting pump house , & switchyard. AC lighting load will be connected to this system which will be normally 'ON'. The lighting panels of this system will be connected to the Emergency lighting board which is fed from diesel generator during the emergency. 25% of lighting fixtures shall be connected on AC emergency lighting.

1.1.4 D.C. Emergency lighting

A few DC emergency lighting fixtures operated on the DC system will be provided in the strategic locations including staircase, corridors, electrical rooms, Battery charger room, LT switchgear room in control room building, and Fire fighting pump house so that the operating personnel can safely find their way even during emergency of a total AC failure. These lights will be normally 'OFF' and will be switched 'ON' automatically when under voltage occurs in the AC main lighting distribution board. GLS lamp down lighters in false ceiling area and Bulkhead fixtures in non false ceiling area to be used.

1.1.5 **Exit Lightings**

All Exit lightings in the buildings shall be fed by DC lighting panels. All necessary wiring and its termination shall be in the contractor’s scope.

1.1.6 The lighting layout for and around Control Room Cum Administrative Office Building & Fire fighting Pump House indicating the type & BOQ for items shall be prepared and submitted by the contractor for owner’s approval during detailed engineering.

The lux levels to be maintained in the switchyard shall be as per following:

Sl No	Area	Average Lux Level
1.	Control Room Building, Firefighting pump house, GIS Building and Indoor Switchyard Building	**SN. Area Average Lux level at floor level** i) Control Room & Conference - room 350 Lux ii) Battery room, Passage, - Pantry, Toilets, Corridors etc. 100 Lux iii) All other rooms - and Buildings including township 200 Lux
2.	Switchyard	-50 lux on main Equipments (i.e,Transformer, Reactor ISO, CB, CT, CVT, SA) at first level (Equipment connections level.) -20 lux on balance area of switchyard and street / Road at ground level. --10 lux (Area between fence and peripheral roads around the switchyard). The lighting between the fence and the peripheral road around switchyard shall be done by providing the lighting fixtures on lighting pole of suitable height, if required.

The minimum lux level to average lux level ratio should not be less than 0.6 (i.e Emin/Eav>0.6). The maintenance factor for indoor illumination design shall be considered as 0.8. The surface reflectance for ceiling/wall/floor shall be 50/30/10

For achieving the specified lux levels in the switchyard, the contractor can provide luminaries of 1x400 W/1x250 W and 2x400 W/ 2x250 W flood light as per requirement.

The contractor shall submit detailed calculation for reaching the above Lux level. Contractor shall conform the Lux levels at different locations of the switch yard and street lighting by measurement.

In addition to the normal lighting provided in the switchyard area to maintain the desired lux levels, high beam fixtures(Type SF4- 8 nos) on swivel support shall be provided in strategic locations near equipments for new substations which shall be kept normally OFF and these shall be switched ON in case of maintenance work.

1.1.7 Ceiling fans (1400 mm sweep, AC 230 volts) shall be provided in , fire fighting pump house and non AC rooms in the control room building and township buildings as per the requirements. Wall mounted fans shall be provided in the conference room, control room, shift manager and substation incharge rooms in control room building. Exhaust fans shall be provided in toilets and pantry.

1.1.8 One no. of aluminum ladder of each size shall be supplied by the contractor for maintenance purpose.

1.1.9 The following specific areas are included in the scope of lighting:

(i) Switchyard Area.
(ii) Switchyard Control Room cum Administrative Office Building
(iii) Fire fighting pump house
(iv) Street lighting (peripheral) inside switchyard fencing (Street lighting shall be done using street lighting poles)
v) DG area lighting
vi) LT Transformer area
vii) GIS Building and Indoor Switchyard Building
viii) Township

1.1.10 **For Outdoor Illumination**

The switchyard and street lighting design including lux level calculations, surface illuminance diagram at varying equipment surface levels , detailed drawings showing the lighting layout and Electrical distribution diagram and BOQ for items shall be prepared by the Contractor and submitted for approval. The above layout drawings will include disposition and location of lighting fixtures, receptacles, etc.

1.1.11 **For Indoor Illumination**

The conduit layout drawing for substation buildings, Electrical distribution diagram for substation buildings, & for substation yard etc. shall be prepared by the Contractor. All wiring including telephone wiring (tinned two pair copper) shall be in concealed conduit. Concealed MS junction boxes for sockets and light points shall be provided in all the rooms of Control Room cum Administrative Office Building and Fire Fighting pump house. In case where false ceiling surface conducting is permissible, all down run conduits will be concealed in wall below the false ceiling.

1.1.12 Each cable run shall be tagged with number that appear in the cable schedules. Cables shall be tagged at their entrance and/or exit from any piece of equipment, junction or pull box, floor opening etc.

1.1.13 The tag shall be made up of aluminum with the number punched on it and securely attached to the cable by not less than two turns of G.I. wire. Cable tags shall be rectangular in shape for power cables and circular shape for control cables.

1.1.14 Location of cables laid directly under ground shall be indicated clearly by cable marker made of galvanised iron plate embedded in concrete block.

1.1.15 The location of under ground cable joints if any, shall be clearly indicated with cable marker with an additional inscription "cable joint".

1.1.16 The marker, which is a concrete block, shall project 150 mm above ground and shall be spaced at an interval of 30 meters and at every change of direction. It shall also be located on both sides of the road or drain crossing.

1.2 LIGHTING SYSTEM FOR TOWNSHIP

1.2.1 The scope of work comprises of design, engineering, testing, supply, installation, testing and commissioning of 400 V, 400Amp, Main Township Distribution board/Energy meter Boards/Flat DBs etc., Power and Control cables, various lighting fixtures complete with lamps, supports and accessories, ceiling fans complete with electronic regulators, exhaust fans for toilets and pantry & accessories, lighting panels, lighting poles complete with distribution boxes, galvanized rigid steel/PVC conduits, lighting wires, G.I. Earthwire, receptacles, tag block & telephone socket, bells, boxes for telephone/television & Air-conditioners points, switchboards, switches, junction boxes, pull out boxes complete with accessories for various type of quarters, parking, pump house, recreation centre and transit camp associated with township.

The township lighting design including lux level calculations, surface illuminance diagram at varying equipment surface levels , detailed drawings showing the lighting layout and Electrical distribution diagram and BOQ for items shall be prepared by the Contractor and submitted for approval. The above layout drawings will include disposition and location of lighting fixtures, receptacles, etc.

1.2.2 SYSTEM DESCRIPTION

The township lighting system shall comprise of the following:

1.2.3 EXTERNAL ELECTRIFICATION WORKS

The entire External Electrification work including connection to various quarters, recreation centres & transit camp associated with township including street lighting of township shall be in the scope of the contractor. 400V,400A, MainTownship distribution board shall be fed from 400V, Main switchboard (being supplied under LT switchgear package) through 2-3 ½ x300 sqmm XLPE insulated power cable from each source. Supply of MainTownship DB & associated 3 ½ x300 sqmm XLPE cable alongwith its interconnection, installation etc shall be in the scope of contractor.

The entire external electrification work comprising of feeder pillars, Cables and associated glands and lugs, steel tubular poles, street lights, MS junction boxes, GI pipes for cable protection, danger plates, Hume pipes, fire extinguishers, cable route markers etc as required shall be in the scope of the contractor

1.2.4 INTERNAL ELECTRIFICATION WORKS

The scope shall broadly consist of entire concealed conduit work, wiring for lights/power/fans/telephones/cables & air-conditioners, supply and fixing of metal boxes, plates, switches, sockets, call bells, buzzers, exhaust fans, ceiling fans, MCBs, MCCBs, light fittings, energy meters boards & flat DBs etc as per the requirements of various quarters, recreation centres and transit camps.

In addition to above complete earthing (through separate earth pit) and lightning protection for each type of quarters ,recreation centre and transit camp shall be provided as per standard guidelines and code of practices. The complete drawing for earthing and lightning protection shall be submitted to owner for approval. The loop earthing inside the buildings shall be carried out with minimum 1Cx1.5 sqmm PVC stranded Copper wire . All materials required or earthing and lightning protection of township buildings shall be in the scope of contractor.

2.0 **DESCRIPTION OF ITEMS**

2.1 ***DESCRIPTION OF ITEMS FOR SUBSTATION LIGHTING***

The Contractor shall supply and install the following equipment and accessories in accordance with the specification.

2.1.1 **LIGHTING PANELS**

2.1.1.1 OUTDOOR

400 AC lighting panel with 400V, 63A, 3 phase 4 wire bus and one no. 63A, TPN, MCB with neutral unit as incomer and 20A, SP MCB as outgoing feeders, the details are as follows.

Type Of Panel	Description	Detail Of Outgoing Feeders
ACP 2	Outdoor	6 nos- 20 A single pole MCB and 3 No. 32 A Triple pole MCB with Neutral and suitable timer and contactor for automatic switching.
ACP 3	Outdoor Street lighting Panel	3 nos.-32A Triple pole MCB with Neutral with suitable timer and contactor for automatic switching

Note: The number of outgoing feeders indicated above are the minimum.

2.1.1.2 **INDOOR**

400 V indoor AC lighting panel ,63 A 3 phase 4 wire bus and one number 63 amp FP MCB with 300ma 63 A FP RCCB. Flush mounted with per phase isolation and LED indication lamps . The DB will be flush mounted and double door type.

Type Of Panel	Description	Detail Of Outgoing Feeders
ACP 1	Indoor	18 nos outgoing ,16 Amps SP MCB

220V DC indoor type change over board and 220V DC 32A two wire bus and one 32A contractor backed up by 32A double pole MCB as incomer. The panel shall have local push button controls. Following are the various types of panels required with control timer.

Type Of Panel	Description	Detail Of Outgoing Feeders
DCP	Indoor	6 nos outgoing ,16 Amps DP MCB

2.1.1.3 **Sub-Lighting Panels**

Type Of Panel	Description	Detail Of Outgoing Feeders
SLP	Outdoor	4 pole 32A Isolator suitable for 400V, 50 cycles AC supply, wlith LILO facility using 8 nos terminal blocks suitable for cable upto 16 mm sq cable

		Enclosure shall be suitable for outdoor use with IP-55 degree of protection as per IEC:60529.

2.1.2 **Lighting Fixtures**

Please Refer Annexure-1

2.1.3 **RECEPTACLES**

	Description	Detail Of Outgoing Feeders
RO	Outdoor	15A, 230V, Receptacle 2 pole, 3- pin type
RP	Outdoor	63A, 400V, Interlocked switch socket, receptacle
RI	Indoor	5/15A, 230V, Receptacle 3-pin type (Modular)

2.1.4 (a) **SWITCH BOARDS**

Modular type switches, 5/15 Amp. Receptacles.

2.1.4 (b) **CONDUITS AND ACCESSORIES**

Galvanised Rigid steel or Rigid PVC conduits of 20/25 /32 mm for Lighting and Telephone wiring

2.1.5 **JUNCTION BOXES -** with 5 Nos.of terminal blocks

2.1.6 **LIGHTING POLES -** (Type A1 poles & Type E1 poles)

2.1.7 **FANS-**1400 mm Sweep with Electronic regulator and 450 mm Wall Mounted fans

2.1.8 **MAINTENANCE EQUIPMENT**

i) A type Aluminium ladder of 3 mtr vertical height.

ii) Cartwheel mounted aluminium ladder Vertical Extendable from 5.1m to 11m.

2.1.9. **RECEPTACLES**

a) All receptacles shall be of cast steel/aluminium, heavy duty type, suitable for fixing on wall/column and complete with individual switch.

b) In general the receptacles to be installed are of the following types :

i) **Type RO**-15A, 230V, 2 pole, 3 pin type with third pin grounded, metal clad with gasket having cable gland entry suitable for 2Cx6 sq.mm. PVC/aluminium armoured cable and a metallic cover tied to it with a metallic chain and suitable for installation in moist location and or outdoor. The switch shall be of rotary type. Receptacles shall be housed in an enclosure made out of 2 mm thick Gl sheet with hinged doors with padlocking arrangements. Door shall be lined with good quality gasketing. This shall conform to IP-55.

ii) **Type RI-**The 5/15 amp 6 pin receptacles with switches will be of Modular type with flush type switches and electroplated metal enclosures of approved make

iii) **Type RP** - 63A, 400V, 3 phase, 4 pin interlocked plug and switch with earthing contacts. Other requirements shall be same as type RO. The receptacle shall be suitable for 3.5C x 35/3.5Cx70 sq.mm. aluminium conductor cable entry and shall also be suitable for loop-in and loop out connection of cables of identical size. Receptacle shall be suitable for outdoor application. Receptacles shall be housed in a box made out of 2mm thick G.I. sheet, with hinged door with padlocking arrangement. Door shall be lined with good quality gasketing. This shall conform to IP-55.

2.1.10. **LIGHTING PANELS (L.P.)**

2.1.10.1 Each panel shall be provided with one incoming triple pole MCB with neutral link and outgoing miniature circuit breakers as per clause 2.0. The panels shall conform to IEC: 60439.

2.1.10.2 **Constructional Features**

a) Panels shall be sheet steel enclosed and shall be dust, weather and vermin proof. Sheet steel used shall be of thickness not less than 2.00 mm (cold rolled) smoothly finished, levelled and free from flaws. Stiffners shall be provided wherever necessary.The indoor lighting panels will be ready made DB of minimum 1.6 mm sheet thickness .

b) The panels shall be of single front construction, front hinged and front connected, suitable for either floor mounting on channels, sills or on walls/columns by suitable M.S. brackets. Indoor panels in control room shall be flush mounted.

c) Panels shall have a dead front assembly provided with hinged door(s) and out door panels will be with padlocking arrangement with single key supplied in duplicate.

d) All out door panels, removable covers, doors and plates shall be gasket all around with neoprene gaskets.

e) The outdoor panels shall be suitable for cable/conduit entry from the top and bottom. Suitable removable cable gland-plate shall be provided on the top and bottom of panels. Necessary number of double compression cable gland shall be supplied, fitted on to this gland plate. The glands shall be screwed on top and made of tinned brass.

f) The panels shall be so constructed as to permit free access to connection of terminals and easy replacement of parts.

g) Each panel shall have a caution notice fixed on it.

h) Each panel will be provided with directory holder in which printed and laminated as built circuit directory would be kept inside a document holder/pasted at site.

i) Each Outdoor lighting panel shall be provided with one no. 'ON' indicating lamp for each phase alongwith fuses. For indoor lighting panels din mounted phase indication lamps will be provided, mounted along side of the MCB

j) **Main Bus Bars**

Bus bars shall be of aluminium alloy conforming to IEC: 60114/60105 and shall have adequate cross-section to carry the rated continuous and withstand short circuit currents. Maximum operating temperature of the bus bars shall not exceed 85 deg. C. The bus bars shall be able to withstand a fault level of 9 kA for 1 sec. for AC panels and 4 KA for 1 sec. for DC panels. The Indoor lighting panels shall have copper bus bar

2.1.10.3 JUNCTION BOXES

a) The junction boxes shall be concealed type for indoor lighting and suitable for mounting on columns, lighting poles, structures etc., for outdoor lighting.

b) Junction boxes shall be of square/rectangular type of 1.6 mm sheet steel with minimum 6 mm thick pressure diecast aluminium material LM-6 and shall have bolted cover with good quality gasket lining.

c) The junction box and cover of sheet steel construction shall be hot dip galvanised.

d) The junction boxes shall be complete with conduit knockouts/threaded nuts and provided with terminal strips .The junction boxes shall be suitable for termination of Cable glands of dia 20 mm, 25 mm, 32 mm, 40 mm on all sides. The junction boxes shall be provided with 4 way terminals suitable for two numbers 10 sq. mm. wire & for street lighting/switchyard lighting suitable for 2 numbers 4C x 16 Sq.mm Al. cable.

e) The junction boxes shall have the following indelible markings

(i) Circuit Nos. on the top.
(ii) Circuit Nos. with ferrules (inside) as per drawings.
(iii) DANGER sign in case of 400 volt junction box.

f) The junction boxes shall be weather proof type with gaskets conforming to IP 55 as per IEC: 60529.

2.1.10.4 **Occupancy Sensors:**

Sufficient number of occupancy sensors shall be provided in the stairs area and corridors of control room cum administrative building and GIS Building. Each occupancy sensor shall be used for indoor use with time delay programmable in the minimum range of 1 sec. to 2 Hour to control the illumination in the area.

2.2 DESCRIPTION OF FCOMMON ITEMS FOR LIGHTING

2.2.1 LIGHTING FIXTURES AND ACCESSORIES

2.2.1.1 General

All lighting fixtures and accessories shall be designed for continuous operation under atmospheric conditions existing at site, without reduction in the life or without any deterioration of materials, internal wiring.

2.2.1.2 Temperature Rise

All lighting fixtures and accessories shall be designed to have a low temperature rise according to the relevant International standard. The design ambient temperature shall be taken as 50 deg.C.

2.2.1.3 Supply Voltage

Lighting fixtures and accessories meant for 230V A.C. operation shall be suitable for operation on 230V A.C. 50Hz, supply voltage variation of ± 10%, frequency variation of ± 2.5% and combined voltage and frequency variation of ± 10%.

Lighting fixture and accessories meant for 220V DC operation shall be suitable for operation on 220V DC with variation between 190 to 230 Volts.

2.2.1.4 **Lighting Fixtures**

a) The lighting fixtures shall be Philips or equivalent International make except for fixtures type 'DSM' & 'HL' for which make has been specified elsewhere in this chapter. The different types of lighting fixtures are also indicated elsewhere in this Chapter.

b) All fixtures shall be designed for minimum glare. The finish of the fixtures shall be such that no bright spots are produced either by direct light source or by reflection.

c) All lighting fixtures shall be complete with fluorescent tubes / incandesent lamps/mercury vapour/sodium vapour lamps as specified and shall be suitably wired up.

d) All flourescent lamp fixture shall be complete with all accessories like ballasts, power factor improvement capacitors, lamps, starters, holders etc.

e) High beam fixtures shall be suitable for pendant mounting and flood lights shall have suitable base plate / frame for mounting on steel structural member. Hook mounted high beam fixtures are not acceptable.

f) Each lighting fixture shall be provided with an earthing terminal suitable for connection to 16 SWG GI earthing conductors.

g) All light reflecting surfaces shall have optimum light reflecting co-efficient such as to ensure the overall light output as specified by the manufacturer.

h) Height of fixtures should be such that it is easy to replace the lamps with normal ladder/stool. In case the ceiling height is very high, the fixtures may be placed on the walls for ground lighting.

2.2.1.5 **ACCESSORIES**

2.2.1.5.1 **Lamp holders and Starter Holders**

(a) Lamp holders/starter holders for fluorescent tubes shall be of the spring loaded, low contact resistance, bi-pin rotor type, resistant to wear and suitable for operation at the specified temperature, without deterioration in insulation value, contact resistance or retention of the lamp/starter. They shall hold the lamp/starter in position under normal condition of shock and vibration.

(b) Lamp holders/starter for incandescent lamps and HPMV/HPSV lamps shall be of screwed type, manufactured in accordance with relevant standard and designed to give long and satisfactory service.

2.2.1.5.2 **Ballasts**

a) All HPSV/HPMV/Metal halide lamp fixtures shall be provided with wire wound ballasts. All fluorescent fixtures shall be provided with high frequency electronic ballasts. The Ballasts shall be designed, manufactured and supplied in accordance with relevant standard and function satisfactorily under site condition specified. The ballasts shall be designed to have a long service life and low power loss.

b) Ballasts shall be mounted using self locking anti-vibration fixing and shall be easy to remove without dismantling the fixtures. They shall be totally enclosed units.

c) The wire-wound ballasts shall be of the inductive, heavy duty type, filled with thermosetting insulating moisture repellent polyester compound filled under pressure or vacuum. The ballast wiring shall be of copper wire. They shall be free from hum. Ballasts which produce humming sound shall be replaced free of cost by the Contractor. Ballasts for high pressure mercury vapour/ HPSV lamps shall be provided with suitable tappings to set the voltage within the range specified. End connections and taps shall be brought out in a suitable terminal block, rigidly fixed to the ballast enclosure.

d) Separate ballast for each lamp shall be provided in case of multi-lamp fixtures.

e) High frequency electronic ballasts shall be capable of satisfactory performance in adverse environment like that of EHV substation. Ballasts shall consist of AC/DC converter, high frequency power oscillator and low pass filter. The ballasts shall be suitable for use of nominal voltage of 230V +/- 10%, 50 Hz supply. The filter circuit shall suppress the feedback of high frequency signals to the mains. The ballast shall be rated for 36/40W fluorescent fixtures. The ballasts shall confirm to IEC 68-2-6FC, IEC 60929 for performance, IEC 60928 for safety and EN 55015, EN 55022A for RFI and EN 61003.

2.2.1.5.3 **Capacitors**

a) The capacitors shall have a constant value of capacitance and shall be connected across the supply of individual lamp circuits.

b) Power factor of fluorescent lamp fixtures with HF electronic ballast shall not be less than 0.90 and that of High pressure Sodium Vapour, Mercury Vapour and Metal Halide lamp fixtures shall not be less than 0.85. The capacitors shall be suitable for operation at supply voltage as specified and shall have a value of capacitance so as to correct the power factors of its corresponding lamp circuit to the extent of 0.98 lag.

c) The capacitors shall be hermetically sealed in a metal enclosure.

2.2.1.5.4 **Lamps**

a) General Lighting Services (GLS) lamps shall be provided with screwed caps and shall be of 'clear' type unless otherwise specified.

b) The Bidder shall furnish typical wiring diagram for Fluorescent, HPMV & HPSV fitting including all accessories. The diagram shall include technical details of accessories i.e. starters, chokes, capacitors etc.

c) Flexible conduits if required, for any fixture shall be deemed to be included in Contractor's scope.

2.2.1.5.5 **SWITCH AND SWITCHBOARD**

(a) All Switch board/boxes, 5/15 Amp Receptacles and electronic fan regulators located in office/building areas shall be modula**r** flush mounted type or brick wall with only the switch knob projecting outside.

(b) Switch boards/boxes shall have conduit knock outs on all the sides.

(c) The exact number of switches including regulator for fans and layout of the same in the switchboard shall be to suit the requirement during installation.

(d) The maximum number of luminaires , controlled by one no 6 amp switch would 4 nos. For DC fixtures there will be no switch and the same shall be directly controlled from DC LP

(e) The luminaires shall be wired in such a fashion that luminaires on each phase are evenly distributed all over the room.

2.2.1.5.6. **CONDUITS & CONDUIT ACCESSORIES**

a) The conduits shall conform to IEC: 61386 or IEC: 61035 or IEC: 60614 as applicable. All steel conduits shall be seemed by welding, shall be of heavy gauge and shall be hot dip galvanised.

b) Flexible conduits wherever required shall be made with bright, cold rolled annealed and electro-galvanised mild steel strips or PVC/Plastic.

c) All conduits accessories shall conform to relevant IEC and shall be hot dip galvanized or High quality virgin PVC.

2.2.1.5.7 **TERMINAL BLOCKS**

Each terminal shall be suitable for terminating upto 2 Nos. 10 sq.mm. stranded Aluminium Conductors without any damage to the conductors or any looseness of connections. Terminal strips provided in street - lighting poles shall be suitable for terminating upto 2 nos. 4C x 16 sq. mm aluminium cables.

2.2.1.5.8 **PULL OUT BOXES**

a) The pull out boxes shall be concealed type for indoor lighting and suitable for mounting on column, structures etc., for outdoor lighting. The supply of bolts, nuts and screws required for the erection shall be included in the installation rates.

b) The pull out boxes shall be circular of cast iron or 16 SWG sheet steel and shall have cover with good quality gasket lining.

c) The pull out boxes and cover shall be hot dip galvanised.

d) The pull out boxes shall be completed with conduit knock outs/threaded hubs and provided at approximately 3 meters intervals in a conduit run.

2.2.1.5.9 **Residual Current Circuit Breakers** (**RCCB)**

For indoor panels 63A 4pole 300 ma RCCB conforming IEC 13947 will be provided along with incomer.

2.2.1.5.10 **Miniature Circuit Breaker (MCB)**

a) The miniature circuit breakers shall be suitable for manual closing, opening, automatic tripping under overload and short circuit. The MCBs shall also be trip free. MCB of Type C tripping characteristics as per IEC: 60898 will be used for Switchyard lighting.

b) Single pole as well as three pole versions shall be furnished as required in the Schedule of Lighting Panels.

c) The MCBs and panel MCCB together shall be rated for full fault level. In case the MCB rating is less than the specified fault level the bidder shall co-ordinate these breaker characteristics with the back up MCCB in such a way that if fault current is higher than breaker rating, the MCCB should blow earlier than the breaker. If the fault current is less than MCB breaking capacity, MCB shall operate first and not the incomer MCCB.

d) The MCBs shall be suitable for housing in the lighting panels and shall be suitable for connection with stranded copper wire connection at both the incoming and outgoing side by copper lugs or for bus bar connection on the incoming side.

e) The terminals of the MCBs and the 'open' 'close' and 'trip' conditions shall be clearly and indelibly marked.

f) The tenderer shall check and co-ordinate the ratings of MCBs with respect to starting characteristics of discharge lamps. The vendor has to furnish overload and short circuit curve of MCB as well as starting characteristics curves of lamps for Employer's approval.

g) The MCB shall generally conform to IEC: 60898.

2.2.1.5.11 **Contactors**

Contactors shall be of the full voltage, direct-on line air break, single throw, electro-magnetic type. They shall be provided with atleast 2-'NC' and 2'NO' auxiliary contacts. Contactor shall be provided with the three element, positive acting, ambient temperature compensated time lagged, hand reset type thermal overload relay with adjustable settings to suit the rated current. Hand reset button shall be flush with the front of the cabinet and suitable for resetting with starter compartment door closed. The Contactor shall be suitable for switching on Tungsten filament lamp also. The bidder shall check the adequacy of the Contactors rating wire with respect to lighting load.

2.2.1.5.12 **Push Buttons**

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 their functions. Push buttons shall be of reputed make.

2.2.1.5.13 **Labels**

a) The lighting panels shall be provided on the front with panel designation labels on a 3 mm thick plastic plate of approved type. The letter shall be black engraved on white back ground.

b) All incoming and outgoing circuits shall be provided with labels. Labels shall be made of non-rusting metal or 3 ply lamicold. Labels shall have white letters on black or dark blue background.

2.2.1.5.14 **Earthing Terminals**

Panels shall be provided with two separate and distinct earthing terminals suitable to receive the earthing conductors of size 50x6 G.S. Flat.

2.2.1.5.15 Type test reports for following tests on all lighting panels shall be submitted for approval as per clause 9.2 of Chapter 2: GTR.

(i) Wiring continuity test
(ii) High voltage (2.5 KV for 1 minute) and insulation test
(iii) Operational test
(iv) Degree of protection (not less than IP-55 test on outdoor Lighting Panels and IP-52 test on indoor Lighting Panels as per IEC: 60947 (part 1)
(v) Heat run test

2.2.1.5.16. LIGHTING POLES

a) The Contractor shall supply, store and install the following types of steel tubular lighting poles required for street lighting.

i) Type A1 Street Lighting Pole - for one fixture

ii) Type E1 Post top lantern pole - for one fixture

b) Street/flood light poles shall conform to the enclosed drawings. In front of control room building , and Fire Fighting Buildings, decorative post top lantern (Type E1) poles and Bollards shall be installed.

c) Lighting poles shall be complete with fixing brackets and junction boxes. Junction boxes should be mounted one meter above ground level.

d) The lighting poles shall be coated with bituminous preservating paint on the inside as well as on the embedded outside surface. Exposed outside surface shall be coated with two coats of metal primer (comprising of red oxide and zinc chromate in a synthetic medium).

e) The galvanised sheet steel junction box for the street lighting poles shall be completely weather proof conforming to IP-55 and provided with a lockable door and HRC fuse mounted on a fuse carrier and fuse base assembly. The fuses & junction box shall be as specified in the specification. However, terminals shall be stud type and suitable for 2 nos. 16 sq.mm. cable.

f) Wiring from junction box at the bottom of the pole to the fixture at the top of the pole shall be done through 2.5 sq. mm wire.

g) Distance of centre of pole from street edge should be approximately 1000 to 1200 mm.

h) Earthing of the poles should be connected to the switchyard main earth mat wherever it is available and the same should be earthed through 3M long, 20 mm dia, earth electrode.

2.2.1.5.17 CEILING & WALL MOUNTED FANS AND REGULATORS

a) The contractor shall supply and install 1400 mm sweep ceiling fans complete with electronic regulator and switch, suspension rod, canopy and accessories. The wall mounted fans shall be of 400 mm sweep

b) The contractor shall supply and install the switch, electronic regulator and board for mounting switch and electronic regulator for celling fans. The regulator will be housed in common switchboard for lighting and shall be of similar make and model as that of modular switches.

c) Winding of the fans and regulators shall be insulated with Class-E insulating material. Winding shall be of copper wire.

d) Electronic regulator with stepped control shall be provided.

2.2.1.5.18 **LIGHTING WIRES**

a) The wiring used for lighting shall be standard products of reputed manufacturers.

b) The wires shall be of 1100 V grade, PVC insulated product of reputed manufacturers.

c) The conductor sizes for wires used for point wiring beyond lighting panels shall be 2.5 sq.mm, 4 sq.mm, 6 sq.mm and 1.5 sq.mm stranded copper wire.

d) The wires used for connection of a lighting fixture from a nearest junction box or for loop-in loop-out connection between two fluorescent fixtures shall be single core copper stranded conductor, 1100V grade flexible PVC insulated cords, unsheathed, conforming to IEC:60502 with nominal conductor cross sectional areas of 2.5 sq. mm.

e) The wires shall be colour coded as follows:

Red for R - Phase
Yellow for Y - Phase
Blue for B - Phase
Black for Neutral
White for DC (Positive)
Grey for DC (Negative)

2.2.1.5.19 **LIGHTING SYSTEM INSTALLATION WORKS**

2.2.1.5.19.1 **General**

In accordance with the specified installation instructions as shown on manufacturer's drawings or as directed by Employer, Contractor shall unload, erect, install, test and put into commercial use all the electrical equipment included in the contract. Equipment shall be installed in a neat, workmanship manner so that it is level, plumb square and properly aligned and oriented. Tolerances shall be as established in manufacturers drawing or as stipulated by Purchaser.

All apparatus, connections and cabling shall be designed so as to minimize risk of fire or any damage which will be caused in the event of fire.

2.3.1.5.19.2 **Conduit System**

a) Contractor shall supply, store and install conduits required for the lighting installation as specified. All accessories/fittings required for making the installation complete, including but not limited to pull out boxes (as specified in specification ordinary and inspection tees and elbow, checknuts, male and female bushings (brass or galvanised steel), caps, square headed make plugs, nipples, gland sealing fittings, pull boxes, conduits terminal boxes, glands, gaskets and box covers, saddle terminal boxes, and all steel supporting work shall be supplied by the Contractor. The conduit fittings shall be of the same material as conduits. The contractor shall also supply 20 mm PVC conduit and accessories for telephone wiring.

b) All unarmoured cables/wires shall run within the conduits from lighting panels to lighting fixtures, receptacles. etc.

c) Size of conduit shall be suitably selected by the Contractor.

d) Conduit support shall be provided at an interval of 750 mm for horizontal runs and 1000 mm for vertical runs.

e) Conduit supports shall be clamped on the approved type spacer plates or brackets by saddles or U-bolts. The spacer plates or brackets in turn, shall be securely fixed to the building steel by welding and to concrete or brick work by grouting or by nylon rawl plugs. Wooden plug inserted in the masonary or concrete for conduit support is not acceptable.

f) Where conduits are along with cable trays they shall be clamped to supporting steel at an interval of 600 mm.

g) For directly embedding in soil, the conduits shall be coated with an asphalt-base compound. Concrete pier or anchor shall be provided wherever necessary to support the conduit rigidly and to hold it in place.

h) For long conduit run, pull boxes shall be provided at suitable intervals to facilitate wiring.

i) Conduit shall be securely fastened to junction boxes or cabinets, each with a lock nut inside and outside the box.

j) Conduits joints and connections shall be made through water-tight and rust proof by application of a thread compound which insulates the joints. White lead is suitable for application on embedded conduit and red lead for exposed conduit.

k) The entire metallic/PVC conduit system, shall be embedded, electrically continuous and thoroughly grounded. Where slip joints are used, suitable bounding shall be provided around the joint to ensure a continuous ground circuit.

l) Conduits and fittings shall be properly protected during construction period against mechanical injury. Conduit ends shall be plugged or capped to prevent entry of foreign material.

2.2.1.5.19.3 **Wiring**

a) Wiring shall be generally carried out by PVC insulated wires in conduits. All wires in a conduit shall be drawn simultaneously. No subsequent drawings of wires is permissible.

b) Wires shall not be pulled through more than two equivalent 90 deg. bends in a single conduit run. Where required, suitable junction boxes shall be used.

c) Wiring shall be spliced only at junction boxes with approved type terminal strip.

d) For lighting fixtures, connection shall be teed off through suitable round conduit or junction box, so that the connection can be attended without taking down the fixture.

e) For vertical run of wires in conduit, wires shall be suitably supported by means of wooden/hard rubber plugs at each pull/junction box.

f) Maximum two wires can be terminated to each way of terminal connections.

g) Separate neutral wires are to be provided for each circuit.

h) AC and DC wiring should not run through the same conduit.

2.2.1.5.19.4 **Lighting Panels**

a) The lighting panels shall be erected at the locations to be finalised during detailed engineering.

b) Suitable foundations/supporting structures for all outdoor type lighting panels shall be provided by the Contractor.

2.2.1.5.19.5 **Foundation & civil works**

a) Foundation for street lighting poles, panel foundation and transformer foundation shall be done by the Contractor. The payment towards execution, PCC & RCC shall be made under relevant items of civil work mentioned in Bid Price schedule.

b) All final adjustment of foundation levels, chipping and dressing of foundation surfaces, setting and grouting of anchor bolts, sills, inserts and flastening devices shall be carried out by the Contractor including minor modification of civil works as may be required for erection.

c) Any cutting of masonary / concrete work, which is necessary shall be done by the Contractor at his own cost and shall be made good to match the original work.

ANNEXURE-1

SI. No.	Type of Lighting Fixture	Description	Philips Catalogue No
1	F1	2x28W T5 type fluorescent lamps in industrial reflector type fixture, complete with accessories and suitable for pendent /surface mounting.	TMS 122/228 HF
2	FF	2x28 T5 energy efficient fluorescent lamps with low glare, mirror optics suitable for recess mounting type lighting fixture.	TBS 088/228 C5 HF
3	FL	2x28W T5 energy efficient fluorescent lamps with low glare mirror optics suitable for pendent/surface mounting with all accessories	TCS 398/228 D6 HF
4	TL	Sleek and Functional electronic decobatten suitable for use with 1x'TLD'36W fluorescent lamp with dual tone end caps. Pre-phosphated & powder coated CRCA steel channel complete with all electrical accessories like electronic ballast, lamp holders all prewired up to a terminal block	TMS500/136 HF
5	IB	60/100w GLS lamp in Bulkhead fixtures with Cast Aluminium alloy body, suitable for column, wall,and ceiling mounting finished stove enameled silver grey outside	NXC101
6	BL	Aesthetic wall/ceiling mounted luminaire suitable for 1x PL-C 13W OR 11W CFL. Low loss O.C. Copper ballast.Built in high gloss anodized reflector. Twin finish UV stabilised SAN diffuser for protection & elimination of lamp glare.	FMC21/113
7	SL	Aesthetic ceiling mounted luminaire for Ecotone crystal/Décor CFL of 2x9W or 1x18W. ABS housing pre-wired with porcelain lampholder. Pre-phospated plated CRCA gear tray.	FL343/118
8	BH	Bulkhead luminaire suitable for use with PL-S 9W CFL. Single piece pressure die-cast aluminium & cover retaining Frame. Opal acrylic cover along with a gasket made of E.P.R..	FXC 101/109
9	BLD	2X9 Or 1x18 watt CFL bollard light for landscape lighting having FRP/LLDPE housing	FGC202 /118
10	DLR	2x18 watt CFL Downlighter with HF ballast suitable for recess mounting	FBH145/218L HF
11	DSM	1X13 WATT surface mounted CFL	FCS100/113
12	IF	Incandescent GLS lamp down light	DN622

13	SF1	1 X 400W HPSV lamps in high flood lighting fixture with integral control gear	SWF 330/1X400
14	SF2	2 X 400W HP sodium Vapour lamps in high flood lighting, non-integral control gear:	RVP302/2x400W
15	SF3	1 X 250W HPSV lamps in high flood lighting fixture with integral control gear:	SWF 330/1X250
16	SF4	150W HP Metal halide MHN-TD lamp in flood lighting fixture with integral control gear.	SWF230/150 MHN-TD
17	SF5	125 HP MV Lamp in weather proof post top lantern for mounting on pole top	HPC-101/125 HPF
18	SC	150W SON-T Tubular Sodium Vapour lamp in street lighting	SRX-51/150

CHAPTER-10

AIR CONDITIONING SYSTEM

1 GENERAL

1.1 This specification covers supply, installation, testing and commissioning and handing over to NEA of Air conditioning system for the control room building and switch-yard panel rooms.

1.2 Air conditioning units for control room building shall be set to maintain the inside DBT at 24 ^{o} C ± 2^{o}C and the air conditioning system for switch-yard panel rooms shall be set to maintain DBT inside switch-yard panel rooms below 24^{o}C.

1.3 Controllers shall be provided in Control room and Battery room for controlling and monitoring the AC units in these rooms as detailed in clause no.2.3.4.

1.4 Each switch-yard panel room shall be provided with temperature transducer to monitor the temperature of the panel room. The Temperature transducer shall have the following specification:

Sensor	:	Air temperature sensor (indoor use)
Output	:	4 to 20mA
Temperature range	:	-5^{o}C to 60^{o}C
Resolution	:	0.1^{o}C
Accuracy	:	0.5^{o}C or better.

2 AIR CONDITIONING SYSTEM FOR GIS/CONTROL ROOM BUILDING.

2.1 Air conditioning requirement of control room building shall be met using a combination of following types Air Conditioning units as required.

a) Ductable Split unit of 8.5TR.
b) Cassette type split AC units of 3TR.
c) High wall type split AC units of 2TR.

2.2 Scope

The scope of the equipment to be furnished and services to be provided under the contract are outlined hereinafter and the same is to be read in conjunction with the provision contained in other sections/ clauses. The scope of the work under the contract shall be deemed to include all such items, which although are not specifically mentioned in the bid documents and/or in Bidder's proposal, but are required to make the equipment/system complete for its safe, efficient, reliable and trouble free operation.

2.2.1 Required number of Ductable split type AC units of 8.5 TR capacity with air cooled outdoor condensing unit with semi hermetic/hermetic compressors including refrigerant pipes, controls, thermostats, filters, outlet dampers, etc.

2.2.2 Required number of Cassette type split AC units of 3TR capacity each complete with air cooled outdoor condensing unit having hermetically sealed compressor unit with cordless remote controller.

2.2.3 Required number of High wall type split AC units of 2TR capacity each complete with air cooled outdoor condensing unit having hermetically sealed compressor and high wall type indoor evaporator unit with cordless remote controller.

2.2.4 Copper refrigerant piping complete with insulation between the indoor and outdoor units as required.

2.2.5 First charge of refrigerant and oil shall be supplied with the unit.

2.2.6 GSS/Aluminium sheet air distribution ducting for distributing conditioned dehumidified air along with supply air diffusers and return air grilles with volume control dampers and necessary splitters etc., suitable fixtures for grilles/diffusers and supports for ducting complete with insulation.

2.2.7 Local start/stop facility for local starting/ stopping of all electrical equipment/ drives.

2.2.8 All instruments and local control panels alongwith controls and interlock arrangements and accessories as required for safe and trouble free operation of the units.

2.2.9 PVC drain piping from the indoor units upto the nearest drain point.

2.2.10 Supply and erection of Power and control cable and earthing.

2.2.11 MS Brackets for outdoor condensing units, condensers as required.

2.3 **Technical specifications.**

2.3.1 **Ductable split type AC units.**

2.3.1.1 Each Split Air conditioner shall have an indoor unit and an outdoor unit, designed to provide free delivery of conditioned air to the conditioned space. The indoor unit shall be suitable for mounting on the ceiling concealed above the false ceiling. Outdoor unit can be placed on the roof. Each unit shall include a primary source of refrigeration for cooling and dehumidification, means for circulation and cleaning air.

2.3.1.2 Cabinet

The cabinets housing the components of indoor units & outdoor units shall be of heavy gauge sheet steel and suitable for floor mounting/mounting from ceiling. The access panels shall be of easily removable type. The entire casing shall be lined with 25mm thick insulation of totally flame proof type. Suitable drain connection shall be provided for removal of condensate collected inside a tray under cooling coil.

2.3.1.3 Compressor

The compressor shall be Semi hermetically/hermetically sealed type and complete with drive motor. The compressor shall be mounted on spring inside the lower most section of the unit so that it is easily accessible for servicing.

2.3.1.4 Condenser

Air cooled condenser of adequate surface area shall be offered. The air cooled condenser shall be made of copper tubes with external fins.

2.3.1.5 Air Handling Fan

The air handling fan shall be centrifugal type complete with belt drive and electric motor.

2.3.1.6 Filter

Pre-filter at the suctions to remove dust particles down to 10 micron size with 90% efficiency and fine filters to remove dust particles down to 5 micron size with 99% efficiency at the outlet. All filters shall be of panel type.

2.3.1.7 Cooling Coil

Cooling coils shall be of direct expansion type and made of heavy gauge copper with aluminium fins. Rows shall be staggered in the direction of air flow. Separate tubings from the distributor shall feed refrigerant uniformly to different sections of the coil.

2.3.1.8 Refrigerant Piping

Refrigerant piping shall be of heavy gauge copper, heavy class seamless M.S. pipe complete with thermostatic expansion valve, liquid strainer, dehydrator, liquid line shut off valve, high and low pressure gauges.

2.3.1.9 Condensate Trays

An adequate method of condensate removal shall be provided. Condensate tray of adequate size, made of corrosion-resistant material or suitably treated with corrosion-resistant coating shall be provided. The tray shall be adequately insulated to avoid condensation over its external surface.

2.3.1.10 Refrigerant Strainer

A refrigerant strainer shall be provided in the liquid line immediately before the expansion device.

2.3.1.11 Vibration Isolator

A minimum of six 25 thick neoprene rubber pads shall be supplied for each unit.

2.3.1.12 Cooling capacity of 8.5TR unit shall not be less than 102000 btu/hr.

2.3.2 **Cassette type split AC units**.

The Cassette type AC units shall be complete with indoor evaporator unit, outdoor condensing units and cordless remote control units.

2.3.2.1 Outdoor unit shall comprise of hermetically/ semi hermetically sealed compressors mounted on vibration isolators, fans and copper tube aluminium finned coils all assembled in a sheet metal casing. The casing and the total unit shall be properly treated and shall be weatherproof type. They shall be compact in size and shall have horizontal discharge of air.

2.3.2.2 Indoor units shall be of 4-way, ceiling mounted cassette type. The indoor unit shall be compact and shall have elegant appearance. They shall have low noise centrifugal blowers driven by suitable motors and copper tube aluminium finned cooling coils. Removable and washable polypropylene filters shall be provided. They shall be complete with multi function cordless remote control unit with special features like programmable timer, sleep mode etc.

2.3.2.3 Cooling capacity of 3TR AC units shall not be less than 36000btu/hr. and their EER shall not be less than 2.7.

2.3.3 **High wall type split AC units**

2.3.3.1 The split AC units shall be complete with indoor evaporator unit, outdoor condensing units and cordless remote control units.

2.3.3.2 Outdoor unit shall comprise of hermetically/semi hermetically sealed compressors mounted on vibration isolators, propeller type axial flow fans and copper tube aluminium finned coils all assembled in a sheet metal casing. The casing and the total unit shall be properly treated and shall be weatherproof type. They shall be compact in size and shall have horizontal discharge of air.

2.3.3.3 The indoor units shall be high wall type. The indoor unit shall be compact and shall have elegant appearance. They shall have low noise centrifugal blowers driven by suitable motors and copper tube aluminium finned cooling coils. Removable and washable polypropylene filters shall be provided. They shall be complete with multi function cordless remote control unit with special features like programmable timer, sleep mode and soft dry mode etc.

2.3.3.4 Cooling capacity of 2TR AC units shall not be less than 22000btu/hr. and shall have energy efficiency rating of 3star or above.

2.3.4 Controllers shall be provided in Control room and Battery room, one controller for each room, to control and monitoring of AC units and shall have the following facilities;

- Standby units shall come in to operation automatically when the running main unit fails
- Main and standby units shall be changed over periodically which shall be finalised during detailed engineering.
- Following alarms shall be provided:

  a. Compressor On/OFF condition of each unit
  b. Compressor failure of each unit
  c. Power OFF to AC unit
  d. High temperature in room.

2.4 **Warranty**

All compressors shall have minimum 5 years Warranty from the date of commissioning.

CHAPTER 11: FIRE PROTECTION SYSTEM

1.00.00 **INTENT OF SPECIFICATION**

This section covers the design and performance requirements of the following types of fire protection systems;

a. Hydrant System

b. High Velocity Water (H.V.W) Spray System

c. Fire Detection and alarm System

d. Portable Fire Extinguishers

e. Wheel/ Trolley mounted Fire Extinguishers

1.00.01 It is not the intent to completely specify all details of design and construction. Nevertheless, the system design and equipment shall conform in all respects to high standard of engineering, design and workmanship and shall be capable of performing in continuous commercial operation in a manner acceptable to the Owner. The system design shall also conform to NFPA norms.

1.00.02 The scope of work include complete earthwork (i.e. excavation, backfilling etc.) for the entire buried piping for the system, valve pits and pipe supports for buried, entrenched and overground piping.

1.00.03 The equipment offered shall comply with the relevant latest International Standards **unless specified otherwise**. The Deluge valves, HVW spray nozzles & quartzoid bulb detectors shall have the approval of any of the following agencies;

a. UL of USA.
b. F M of USA
c. LPCB of UK or
d. VDS of Germany,

1.00.04 Ambient temperature for design of all equipment shall be considered as 50°C.

1.00.05 The piping and instruments diagram for Hydrant and HVW spray system for 400kV switchyard is enclosed at Appendix-I. respectively. The successful bidder shall prepare detailed layout and piping drawing based on this drawing and other drawings such as road, drainage, cable trench, switch yard layout, etc. as furnished by the Employer during detailed engineering.

2.00.00 DESIGN AND CONSTRUCTION

2.01.00 Hydrant System

Hydrant system of fire protection essentially consists of a large network of pipe, both under ground and over ground which feeds pressurised water to a number of hydrant valves, indoor (if applicable) as well as outdoor. These hydrant valves are located at strategic locations near buildings, Transformers and Reactors. Hose pipes of suitable length and fitted with standard accessories like branch pipes, nozzles etc., are kept in Hose boxes. In case of emergency, these hoses are coupled to the respective hydrant valves through instantaneous couplings and jet of water is directed on the equipment on fire. Hydrant protection shall be provided for the following in all substations of voltage levels 132kV and above (This is not applicable for extension of existing 220kV and 132kV substations where Hydrant system is not available). At least one hydrant post shall be provided for every 60m of external wall measurement of buildings.

a) Control room building/ GIS Hall Building (Whenever applicable)
b) L.T. Transformer area.
c) Fire Fighting pump House.
d) Stores
e) Transformers
f) Shunt Reactors/ Bus Reactors.

2.01.01 A warning plate shall be placed near the hydrant points for the transformers and reactors substations to clearly indicate that water shall be sprayed only after ensuring that the power to the transformer/ reactor which is on fire is switched off and there are no live parts within 20 metres of distance from the personnel using the hydrant.

2.02.00. HIGH VELOCITY WATER (H.V.W) SPRAY SYSTEM

H.V.W. spray type fire protection essentially consists of a network of projectors and an array of heat detectors around the Transformer/Reactor to be protected. On operation of one or more of heat detectors, Water under pressure is directed to the projector network through a Deluge valve from the pipe network laid for this system. This shall be provided for transformers and reactors in all 132kV & above substations (This is not applicable for extension of existing 220kV and 132kV substations where HVWS system is not available). Wet detection initiation system shall be employed for automatic operation.

The system shall be designed in such a way that the same can be extended to protect additional Transformer/ Reactor to be installed in future. However, for the purpose of design it shall be assumed that only one Transformer/ Reactor will be on fire. The main header pipe size in the yard shall be 250mmNB (for 400kV switchyard) and 200mmNB (for 220kV & 132kV switchyard). Branch to the equipment (shall not be more than 20metres length) shall be of the same size as of deluge valve.

2.02.01 The Electrical clearance between the Emulsifier system pipe work and live parts of the protected equipment shall not be less than the values given below:

1.	420 kV bushing	3500 mm
2.	245 kV bushing	2150 mm
3.	145 kV bushing	1300 mm
4.	52 kV bushing	630 mm
5.	36 kV bushing	320 mm

2.02.02 System shall be designed in such a way that the Water pressure available at any spray nozzle shall be between 3.5bar and 5.0bar and shall be demonstrated through hydraulic calculations. Water shall be applied at a minimum rate of 10.2 LPM/M^2 of the surface area of the transformer / Reactor including radiator, conservator, oil pipes, bushing turrets, etc. (including bottom surface for transformer). The nozzle arrangement shall ensure direct impingement of water on all exterior surfaces of transformer tank, bushing turrets, conservator and oil pipes, except underneath the transformer, where horizontal spray may be provided.

2.02.03 **Deluge Valve**

Deluge Valve shall be water pressure operated manual reset type. The Deluge valve shall be closed water tight when water pressure in the heat detector pipe work is healthy and the entire pipe work shall be charged with water under pressure upto the inlet of the Deluge valve. On fall of water pressure due to opening of one or more heat detectors, the valve shall open and water shall rush to the spray water network through the open Deluge valve. The valves shall be manually reset to initial position after completion of operation. Each Deluge Valve shall be provided with a water motor gong which shall sound an alarm when water after passing through the Deluge valve, is tapped through the water motor.

Each Deluge valve shall be provided with a local panel with provision of opening of Deluge valve from local and remote from control room/ remote centre. In addition to this, each valve shall be provided with local operation latch.

Deluge valves of 100mmNB size shall be used if the flow requirement is ≤ 200m^3/hr and 150mmNB size shall be used for flow requirement >200m^3/hr.

Test valves shall simulate the operation of Deluge valves and shall be of quick opening type. The general construction shall conform to requirements under clause no.7.00.00 for piping, valves and specialities.

2.02.04 **High Velocity Spray Nozzles (Projectors)**

High velocity spray system shall be designed and installed to discharge water in the form of a conical spray consisting of droplets of water travelling at high velocity, which shall strike the burning surface with sufficient impact to ensure the formation of an emulsion. At the same time the spray shall efficiently cut off oxygen supply and provide sufficient cooling.

2.02.05 Minimum set point of the heat detectors used in the HVW spray system shall be 79^{o}C. The optimum rating shall, however, be selected by the Bidder, keeping in mind the maximum and minimum temperature attained at site.

2.03.00 **Fire Detection and alarm System**

This system shall be provided for control room building and Switchyard panel rooms of substations**.**

2.03.01 Suitable fire detection system using smoke detectors and/or heat detectors shall be provided for the entire building, including corridor and toilets. Fire detectors shall be located at strategic locations in various rooms of the building. Each Switchyard panel room shall be considered a separate zone. Adequate number of extra zones shall be provided for Switchyard panel rooms for future bays identified in Single line diagram of the substation. The operation of any of the fire detectors/ manual call point should result in the following;

1. A visual signal exhibited in the annunciation panels indicating the area where the fire is detected.
2. An audible alarm sounded in the panel, and
3. An external audible alarm sounded in the building, location of which shall be decided during detailed engineering.
4. If the zone comprises of more than one room, a visual signal shall be exhibited on the outer wall of each room.

2.03.02 Each zone shall be provided with two zone cards in the panel so that system will remain healthy even if one of the cards becomes defective.

2.03.03 Coverage area of each smoke detector shall not be more than 80 m^2 and that of heat detectors shall not be more than 40 m^2. Ionisation type smoke detectors shall be provided in all areas except pantry room where heat detectors shall be provided. If a detector is concealed, a remote visual indication of its operation shall be provided. Manual call points (Break glass Alarm Stations) shall be provided at strategic locations in the control room building. All cabling shall be done through concealed conduits.

2.03.04 Cables used should be exclusively for fire detection and alarm system and shall be 2Cx1.5sq.mm Cu. cables. Un-armoured PVC insulated FR cables conforming to latest IEC / International standards shall be used.

2.04.00 Portable and Wheel/ Trolley mounted Fire Extinguishers

2.04.01 Portable Fire Extinguishers

Adequate number of portable fire extinguishers of pressurised water, dry chemical powder, and Carbon dioxide type shall be provided in suitable locations in control room building and FFPH building as indicated in the drawing. In addition to this one (1) CO2 type fire extinguisher of 4.5kg capacity shall be provided for each Switchyard panel room. These extinguishers will be used during the early phases of fire to prevent its spread and costly damage.

The design, construction & testing of portable fire extinguishers shall meet the requirements as per clause 10.00.00.

2.04.02 Wheel/ Trolley mounted Fire Extinguishers

Wheel/Trolley mounted Mechanical foam type fire extinguishers of 50litre capacity, conforming to latest international standards, shall be provided for the protection of the following:

1. Transformers and reactors in 220kV and 132 kV substations where Hydrant/HVWS system is not available. Two (2) nos. for each 220kV or 132kV transformer and reactor.

2. LT transformers in all substations. One (1) no. for each LT transformer.

The design, construction & testing of Mechanical foam type 50 litre capacity shall meet the requirements of relevant International Codes and clause 10.00.00 of this specification.

2.05.00 Water Supply System

For 400kV and above level substations water for hydrant & HVW system shall be supplied by one electrical motor driven pump of rated capacity 410m3/hr. at 70MWC head, with another pump of same capacity , driven by diesel engine, shall be used as standby. Water storage tank with two compartments of adequate capacity shall be provided. Pumps shall work under positive suction head. Annunciations of the hydrant & HVW spray systems shall be provided in fire water pump house and repeated in control room. Provision for sending data to remote control centre shall also be available.

The outdoor piping for the system in general shall be laid above ground on concrete pedestals with proper supporting arrangement. However, at road/rail crossings, in front/access of buildings, places where movement of cranes/vehicles is expected and at any other place where above ground piping is not advisable, the pipes shall be laid underground. Such locations shall be finalised during detailed engineering.

The whole system will be kept pressurised by providing combination of air vessel and jockey pump of 10.8M^3/hr. capacity at 80MWC. The capacity of air vessel shall not be less than 3m^3. Minor leakage will be met by Jockey pump. One additional jockey pump shall be provided as standby. All pumps shall be of horizontal centrifugal type. Pumps and air vessel with all auxiliary equipment will be located in firewater pump house. A pressure relief valve of suitable rating shall be provided in water header to release excess pressure due to atmospheric temperature variations.

Operation of all the pumps shall be automatic and pumps shall be brought into operation at preset pressure. Fire pumps shall only be stopped manually. Manual start/stop provision shall be provided in local control panel.

2.05.01 The general design of the fire fighting pump sets shall meet the requirements under clauses no.5.00.00 for Horizontal centrifugal pumps, no.6.00.00 for Diesel engines and no.12.00.00 for Electrical motors.

2.05.02 Each pump shall be provided with a nameplate indicating suction lift/delivery head, capacity and number of revolutions per minute.

2.05.03 Design, construction, erection, testing and trial operation of piping, valves, strainers, hydrant valves, hoses, nozzles, branch pipes, hose boxes, expansion joints etc. shall conform to the requirements of clause no. 7.00.00.

2.06.00 **Instrumentation and Control System**

2.06.01 All instruments like pressure indicators, differential pressure indicators, pressure switches, level indicators, level switches, temperature indicators, alarms and all other instruments and panels as indicated in the specification and drawings and those needed for safe and efficient operation of the whole system shall be furnished according to the requirements of clause 11.00.00. Pump running/ fails to start signal shall be taken from the pressure switch immediately after the discharge of the pump.

2.06.02 **Control Panel**

Power feeder for motors will be from switchgear board located in control building but control supply for all local control panels, annunciation panels, battery charger units, space heaters etc. shall be fed from the AC and DC distribution boards located in pump house. These AC & DC distribution boards will be fed from the switchgears and DCDBs located in control building.

a) Panel for motor driven fire water pump

The panel shall be provided with the following:

1.	TPN switch	1 No.
2.	Auto/manual selection facility	
3.	Start/Stop facility with indication lamp	1 Set
4.	DOL starter with thermal O/L relay	1 Set
5.	Indicating lamp showing power ON	1 Set
6.	Indication lamp with drive ON/OF	1 Set
7.	Indication lamp showing Motor Trip	1 No.

Additional provisions shall be made for controlling the following from the remote control centre:

1. Auto/manual selection facility

2. Start/Stop facility

Main power cable from breaker feeder of main switchboard shall be terminated in this panel and another cable shall emanate from this panel which shall be terminated at motor terminals.

b)	Panel for Two nos. Jockey Pump	1No.

The panel shall be provided with the following:

1.	Fuse-switch unit for Jockey pumps	1 Set for each pump
2.	Auto/manual selection facility for eachpump	
3.	Selector switch for selecting either jockey pump	1 No.
4.	D.O.L. starter with overload relay self-resetting type, for all the drives.	1 No. each
5.	Start/stop push button for Jockey Pump with indication lamp with pad-locking arrangements in stop position	1 Set for each pump
6.	Indication lamp for trip indication	1 No. each for pump

Additional provisions shall be made for controlling the following from the remote control centre:

1. Auto/manual selection facility for each pump**.**

a)	Panel for 2 Nos. battery charger & Diesel Engine driven fire water pump	1 No.

The panel shall be provided with the following:

1.	Auto/Manual selection facility for Diesel Engine driven pump	1 No.
2.	Start/Stop facility with indication lamp	1 Set
3.	Indicating lamp showing drive ON/OFF	1 Set
4.	D.C. Voltmeter/Ammeter in the battery charger circuit	1 No. each
5.	Battery charger will be as per specification described	1 Set
6.	Selector switch for selecting either of battery chargers for the battery sets.	1 No.
7.	Selector switch for selecting either set of batteries for Diesel engine starting.	1No.
8.	Selector switch for boost charging/Trickle charging of battery set.	1 Set

Additional provisions shall be made for controlling the following from the remote control centre:

1. Manual Start/Stop of Diesel Engine

d) Individual local control panel is to be considered for each transformer/ Reactor deluge system wherever these equipment are envisaged. This panel shall contain push buttons with indicating lamps for spray ON/OFF operation in the valve operation circuit. Push buttons shall be concealed behind glass covers, which shall be broken to operate the buttons. Provision shall be made in the panel for the field signal for the annunciations such as spray ON and fire in the Transformer/Reactor. A signal for spray ON shall also be provided in the control room fire alarm panel for employer's event logger. Remote operation facility to open the Deluge valve from control room/ remote centre shall also be provided.

2.06.03 **Annunciation Panels**

a) Location: Fire Water Pump House

i) Indicating lamps showing power supply "ON".

ii) Annunciation windows complete with buttons. Details are as follows:

Sl.No.	Description	Number
1.	Electric motor driven fire water pump running	1
2.	Electric motor driven fire water pump fails to start	1
3.	Diesel engine driven fire water pump running.	1
4.	Diesel engine driven water pump fails to start	1
5.	Jockey pump-1 running	1
6.	Jockey pump-1 fails to start	1
7.	Jockey pump-2 running	1
8.	Jockey pump-2 fails to start	1
9.	Fire in Transformer/ Reactor	1 for each equipment
10.	Deluge system operating for Transformer/Reactor	1 for each equipment
11.	Header pressure low	1
12.	Fire in smoke detection system zone (Common Fire Signal)	1
13.	Water storage tank water level low	2

14.	High speed diesel tank level low	1
15.	Spare	10

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b) **Location: Substation Control Room**

i) Indication lamp showing power supply 'ON'

ii) Provision shall be made in the panel for a signal for spray ON for each Transformer/Reactor for owner's use for event logger.

iii) Each Switchyard panel room shall be considered as separate zone for fire detection and alarm system.

iv) Following annunciations shall be provided.

Sl.No.	Description	Number
1.	Fire in Transformer/ Reactor	1 for each equipment
2.	Diesel engine driven fire water pump in operation	1
3.	Motor driven fire water pump in operation	1
4.	Jockey pump in operation	1
5.	Fire fighting Water storage tank level Low	2
6.	Fire/Fault (zone alarm module)	1+1(duplicate) For each zone as applicable
7.	Spare windows complete in all respect, with relays	10

8.	Spare zone alarm modules required for the	Number of future A/c bays identified as per SLD	Kiosks

c) Each annunciation panel shall be provided with a hooter**.** A hooter in parallel to the hooter in fire panel shall be provided in the security room of substation for alert in case of fire.

d) Indication for fault in respective areas shall also be provided. Each zone alarm module shall exhibit 'FIRE' and 'FAULT' conditions separately.

e) **Provision for sending data to Remote Control Unit for the following**

(i) Fire in Switchyard Panel Room (Switchyard Panel room shall be considered as separate zone for fire detection and alarm system).

(ii) Fire in Transformer/Reactor (1 for each equipment)

(iii) Diesel engine driven fire water pump in operation.

(iv) Motor driven fire water pump in operation

(v) Fire/Fault in Control Room.

(vi) Water Storage tank level (low and very low for each storage tank).

(vii) High Speed Diesel tank level (low & very low)

(viii) AC Mains Supply Healthy/Fail for Main Pump & Jockey Pump

(ix) DC Control Supply Healthy/Fail for Main Pump & Jockey Pump

(x) DC Control Supply Healthy/Fail for Diesel Engine driven pump.

2.06.04 The control and interlock system for the fire protection system shall meet the following requirements:

1. **Electric Motor Driven Fire water Pump**

Pump should start automatically when the System header pressure is low.

Pump should be stopped manually only. Pump should also be started manually if required from local control panel.

2. **Diesel Engine Driven Standby Pump**

The pump should automatically start under any of the following conditions:

a) System Header pressure low.

b) Electric motor operated fire water pump fails to start.

Pump should be stopped manually only. Pump should also be started manually if required from the local control panel. The battery set which is connected for starting of Diesel engine shall not be subjected to boost charge.

3. **Jockey Pump**

It shall be possible to select any one of the Jockey pumps as main and the other as standby. Main Jockey pump shall start automatically when water pressure in header falls below the set value. If the main jockey pump fails to start then the standby should start. Jockey pump shall stop automatically when the pressure is restored to its normal value.

Manual starting/stopping shall be possible from the local control panel.

3.00.00 **TESTS**

3.01.00 **Shop Tests**

3.01.01 Shop tests of all major equipment centrifugal pumps, diesel engines, electrical drive motors, piping, valves and specialties, pressure and storage vessels, MCC, electrical panels, controls, instrumentation etc. shall be conducted as specified in various clauses and as per applicable standards/codes.

3.01.02 Shop tests shall include all tests to be carried out at Contractor's works, works of his sub-contractor and at works where raw materials supplied for manufacture of equipment are fabricated. The tests to be carried out shall include but not be limited to the tests described as follows :

a) Materials analysis and testing.

b) Hydrostatic pressure test of all pressure parts, piping, etc.

c) Dimensional and visual check.

d) Balancing test of rotating components.

e) Response of heat/smoke detectors.

f) Performance characteristics of HVW spray nozzles (projectors).

g) Flow rate and operational test on Flow control valves.

h) Operational test of alarm valve (water-motor gang).

i) Calibration tests on instruments and tests on control panel.

j) Destruction/burst tests on 2% or minimum one (1) no. of hoses and portable type fire extinguishers for each type as applicable. Any fraction number shall be counted as next higher integer.

k) Performance test on fire extinguishers as required in the code.

3.01.03 In the absence of any Code/Standard, equipment shall be tested as per mutually agreed procedure between the supplier and the Employer.

3.01.04 A comprehensive visual and functional check for panels would be conducted and will include a thorough check up of panel dimensions, material of construction, panel finish, compliance with tubing and wiring specifications, quality of work-manship, proper tagging & locations of instruments/accessories. The wiring check shall be complete point to point ring out and check for agreement with installation drawings and equipment vendor prints of the complete system and an inspection of all field connection terminals and levelling.

3.01.05 All test certificates and reports shall be submitted to the Employer for approval.

3.01.06 The Employer's representative shall be given full access to all tests. The manufacturer shall inform the Employer allowing adequate time so that, if the Employer so desires, his representatives can witness the test.

3.02.00 **Pre-commissioning Tests**

3.02.01 **General**

a) All piping and valves, after installation will be tested hydraulically at a pressure of 16kg/cm^2 for a period of 30 minutes to check against leak tightness.

b) All manually operated valves/gates shall be operated throughout 100% of the travel and these should function without any trouble whatsoever, to the satisfaction of the Employer.

c) All pumps shall be run with the specified fluid from shut off condition to valve wide open condition. Head developed will be checked from the discharge pressure gauge reading. During the test, the pumps and drives shall run smoothly without any undue vibration, leakage through gland, temperature rise in the bearing parts, noise, flow pulsation etc.

d) All pressure vessels should be tested hydraulically at the specified test pressure, singly or in the system.

e) Painting shall be checked by dry type thickness gauges.

f) Visual check on all structural components, welding, painting etc. and if doubt arises, these will be tested again.

g) All test instruments and equipment shall be furnished by the Contractor to the satisfaction of the Employer.

h) Automatic starting of all the fire pumps by operating the test valves.

i) Automatic operation of the Jockey pump

j) Operation of the Deluge valve by breaking a detector as well as manual and remote operation of the deluge valve.

k) Operation of entire annunciation system.

Replacement of fused/damaged quartzoid bulb detectors during the test shall be responsibility of contractor.

3.02.02 After erection at site, the complete HVW spray protection and hydrant system shall be subject to tests to show satisfactory performance for which detailed procedure shall be submitted for Employer's approval.

Full flow tests with water shall be done for the system piping as a means of checking the nozzle layout, discharge pattern and coverage, any obstructions and determination of relation between design criteria and actual performance, also to ensure against clogging of the smaller piping and the discharge devices by foreign matter carried by the water.

Rigidity of pipe supports shall also be checked during the water flow.

3.02.03 All the detectors installed shall be tested for actuation by bringing a suitable source of heat/smoke near the detector and creating a stream of hot air/ smoke over the detector. The exact procedure of this test shall be detailed out by the Employer to the successful Bidder.

4.00.00 **SPARE PARTS**

The Contractor shall indicate in his scope of supply all the mandatory spares in the relevant schedules. The list of mandatory spares is indicated in 'Section - Projects'.

5.00.00 **HORIZONTAL CENTRIFUGAL PUMPS**

This clause covers the design, performance, manufacturing, construction features and testing of horizontal centrifugal pumps used for the purpose of fire fighting.

5.01.00 The materials of the various components shall conform to the applicable BS/ASTM/DIN Standards.

5.01.01 In case of any contradiction with the aforesaid standards and the stipulations as per the technical specification as specified hereinafter, the stipulations of the technical specification shall prevail.

5.02.00 **General Performance Requirements**

5.02.01 The pump set shall be suitable for continuous operation at any point within the "Range of operation".

5.02.02 Pumps shall have a continuously rising head capacity characteristics from the specified duty point towards shut off point, the maximum being at shut off.

5.02.03 Pumps shall be capable of furnishing not less than 150% of rated capacity at a head of not less than 65% of the rated head. The shut off head shall not exceed 120% of rated head. Range of operation shall be 20% of rated flow to 150% of rated flow.

5.02.04 The pump-motor set shall be designed in such a way that there is no damage due to the reverse flow through the pump which may occur due to any mal-operation of the system.

5.02.05 **Drive Rating**

The drive rating shall not be less than the maximum power requirement at any point within the "Range of Operation" specified.

During starting under reverse flow condition, the motor shall be capable of bringing the pump to rated speed at normal direction with 90% rated voltage at motor terminals.

5.02.06 Pump set along with its drive shall run smooth without undue noise and vibration. Acceptable peak to peak vibration limits shall guided by applicable standards.

5.02.07 The Contractor under this specification shall assume full responsibility in the operation of the pump and drive as one unit.

5.03.00 **Design & Construction**

5.03.01 Pump casing may be axially or radially split. The casing shall be designed to withstand the maximum pressure developed by the pump at the pumping temperature.

5.03.02 Pump casing shall be provided with adequate number of vent and priming connections with valves, unless the pump is made self-venting & priming. Casing drain, as required, shall be provided complete with drain valves.

5.03.03 Under certain conditions, the pump casing nozzles will be subjected to reactions from external piping. Pump design must ensure that the nozzles are capable of withstanding external reactions not less than those specified in API-610.

5.03.04 Pump shall preferably be of such construction that it is possible to service the internals of the pump without disturbing suction and discharge piping connections.

5.03.05 **Impeller**

The impeller shall be secured to the shaft and shall be retained against circumferential movement by keying, pinning or lock rings. On pumps with overhung shaft impellers shall be secured to the shaft by an additional locknut or cap screw. All screwed fasteners shall tighten in the direction of normal rotation.

5.03.06 **Wearing Rings**

Replaceable type wearing rings shall be furnished to prevent damage to impeller and casing. Suitable method of locking the wearing ring shall be used.

5.03.07 **Shaft**

Shaft size selected shall take into consideration the critical speed, which shall be at least 20% away from the operating speed. The critical speed shall also be atleast 10% away from runaway speed.

5.03.08 **Shaft Sleeves**

Renewable type fine finished shaft sleeves shall be provided at the stuffing boxes/mechanical seals. Length of the shaft sleeves must extend beyond the outer faces of gland packing or seal and plate so as to distinguish between the leakage between shaft & shaft sleeve and that past the seals/gland.

5.03.09 Shaft sleeves shall be securely fastened to the shaft to prevent any leakage or loosening. Shaft and shaft sleeve assembly should ensure concentric rotation.

5.03.10 **Bearings**

Bearings of adequate design shall be furnished for taking the entire pump load arising from all probable conditions of continuous operation throughout its "Range of Operation" and also at the shut-off condition. The bearing shall be designed on the basis of 20,000 working hours minimum for the load corresponding to the duty point.

Bearings shall be easily accessible without disturbing the pump assembly. A drain plug shall be provided at the bottom of each bearing housing.

5.03.11 **Stuffing Boxes**

Stuffing box design shall permit replacement of packing without removing any part other than the gland. Stuffing boxes shall be sealed/cooled by the fluid being pumped and necessary piping, fittings, valves, instruments, etc. shall form an integral part of the pump assembly.

5.03.12 **Shaft Couplings**

All shafts shall be connected with adequately sized flexible couplings of suitable design. Necessary guards shall be provided for the couplings.

5.03.13 **Base Plates & Sole Plate**

A common base plate mounting both for the pump and drive shall be furnished.

The base plate shall be of rigid construction, suitably ribbed and reinforced. Base plate and pump supports shall be so constructed and the pumping unit so mounted as to minimise misalignment caused by mechanical forces such as normal piping strain, hydraulic piping thrust etc. Suitable drain taps and drip lip shall be provided.

5.03.14 Material of Construction

All materials used for pump construction shall be of tested quality. Material of construction of the major parts of the pumps shall be as given below or superior as per relevant latest International standards:

a) Casing Casting Grade 17 of BS 1452

b)	Impeller	Bronze Grade LG2-C of BS1400
c)	Wearing ring	Bronze Grade LG2-C of BS1400
d)	Shaft	Mild Steel.
e)	Shaft sleeve	Bronze Grade LG2-C of BS1400
f)	Stuffing box	2.5% Nickel CI Grade 17 of BS 1452
g)	Gland	--- do ---

5.03.15 **Balancing**

All rotating components shall be statically and dynamically balanced at shop.

5.03.16 All the components of pumps of identical parameters supplied under this specification shall be interchangeable.

5.04.00 **Tests and Inspection**

5.04.01 The manufacturer shall conduct all routine tests required to ensure that the equipment furnished conform to the requirements of this specification and are in compliance with the requirements of applicable Codes and Standards. The particulars of the proposed tests and the procedures for the tests shall be submitted to the Employer/Engineer for approval before conducting the tests.

5.04.02 Where stage inspection is to be witnessed by Employer, in addition to above, the Bidder shall submit to the Employer/Engineer at the beginning of the contract, the detailed PERT-Chart showing the manufacturing programme and indicating the period where Employer or his authorised inspecting agency are required at the shop.

5.04.03 **Material of Construction**

All materials used for pump construction shall be of tested quality. Materials shall be tested as per the relevant standards and test certificates shall be made available to the Employer/Engineer.

5.04.04 Where stage inspection is to be witnessed by Employer, all material test certificates shall be correlated and verified with the actual material used for construction before starting fabrication, by Employer's Inspector who shall stamp the material. In case mill test certificates for the material are not available, the Contractor shall carry out physical and chemical tests at his own cost from a testing agency approved by the Employer, as per the requirements of specified material standard.

The samples for physical and chemical tests shall be drawn up in presence of Employer's inspector who shall also witness the tests.

5.04.05 Shaft shall be subjected to 100% ultrasonic test and machined portion of the impeller shall be subject to 100% DP test. On finished shaft DP test will also be carried out.

5.04.06 **Hydraulic test at shop**

All pressure parts shall be subjected to hydraulic testing at a pressure of 150% of maximum pressure generated by the pump at rated speed or 200% of total dynamic head whichever is higher, for a period not less than one (1) hour.

5.04.07 **Performance test at shop**

Pumps shall be subjected to routine tests to determine the performance of the pumps. These tests shall be conducted in presence of Employer/Engineer's representative as per the requirements of the ASME Power Test Code PTC 8.2/BS-599/I.S.S., latest edition. Routine tests shall be done on all the pumps.

5.04.08 Performance tests shall be conducted to cover the entire range of operation of the pumps. These shall be carried out to span 150% of rated capacity upto pump shut-off condition. A minimum of five combinations of head and capacity are to be achieved during testing to establish the performance curves, including the design capacity point and the two extremities of the Range of operation specified.

5.04.09 Tests shall preferably be conducted alongwith the actual drives being supplied.

5.04.10 The Bidders shall submit in his proposal the facilities available at his works to conduct performance testing. If because of limitations of available facilities, a reduced speed test or model test has to be resorted to establish pump performance, the same has to be highlighted in the offer.

5.04.11 In case of model testing, the stipulations of latest edition of apllicable standards shall be binding. Prototype or model tests, however, shall be conducted with the suction condition identical to the field conditions i.e. sigma values of prototype and model is to be kept same.

5.04.12 Prior to conducting model testing, calculations establishing model parameters, sizes and test procedure will be submitted to Employer/Engineer for approval.

5.04.13 All rotating components of the pumps shall be subjected to static and dynamic balancing tests.

5.04.14 The Employer or his authorised representative shall have full access to all tests. Prior to performance tests, the Contractor shall intimate the Employer allowing adequate time so that if the Employer so desires, his representative can witness the test.

5.04.15 Report and test certificates of the above tests shall be submitted to the Employer/Engineer for approval.

5.04.16 **Pre commissioning tests.**

After installation, pumps offered may be subjected to testing at field also by Employer. If the performances at field are not found to meet the requirement, then the equipment shall be rectified by the Contractor without any extra cost. Prior to performance testing, the procedure for such tests will be mutually agreed between Employer and Contractor. The Contractor shall furnish all necessary instruments, accessories and personnel for testing. Prior to testing, the calibration curves of all instruments and permissible tolerance limit of instruments shall be mutually agreed upon.

6.00.00 **DIESEL ENGINES**

This Clause covers the design, performance, manufacturing construction features and testing of compression ignition diesel engines, used primarily for driving centrifugal pumps, used for the purpose of fire fighting.

6.01.00 **Design and Construction**

General

6.01.01 The diesel engine shall be of multicylinder type four-stroke cycle with mechanical (airless) injection, cold starting type.

6.01.02 The continuous engine brake horse power rating (after accounting for all auxiliary power consumption) at the site conditions shall be atleast 20% greater than the requirement at the duty point of pump at rated RPM and in no case, less than the maximum power requirement at any condition of operation of pump.

6.01.03 Reference conditions for rated output of engine shall be as per ISO:3046, part I.

6.01.04 The engine shall be designed with regard to ease of maintenance, repair, cleaning and inspection.

6.01.05 All parts subjected to substantial temperature changes shall be designed and supported to permit free expansion and contraction without resulting in leakage, harmful distortion or misalignment.

6.01.06 **Starting**

The engine shall be capable of both automatic and manual start. The normal mode of starting is automatic but in the event of failure of automatic start or at the discretion of the operator, the engine can be started manually from the LCP.

Since the fire pumping unit driven by the diesel engine is not required to run continuously for long periods and the operation will not be frequent, special features shall be built into the engine to allow it to start within a very short period against full load even if it has remained idle for a considerable period.

6.01.07 If provision for manual start (cranking) is provided, all controls/ mechanisms, which have to be operated during the starting process, shall be within easy reach of the operator.

6.01.08 Automatic cranking shall be effected by a D.C. motor having high starting torque to overcome full engine compression. Starting power will be supplied from either of the two (2) sets of storage batteries. The automatic starting arrangement shall include a 'Repeat Start' feature for 3 attempts. The battery capacity shall be adequate for 3 (three) consecutive starts without recharging with a cold engine under full compression.

6.01.09 The batteries shall be used exclusively for starting the diesel engine and be kept fully charged all the time in position. Arrangement for both trickle and booster charge shall be provided.

Diesel engine shall be provided with two (2) battery charger units of air-cooled design. The charger unit shall be capable of charging one (1) set of battery at a time. Provision shall, however, be made so that any one of the charger units can be utilised for charging either of the two (2) batteries.

6.01.10 For detail design of battery and battery charger, sub- section Electrical may be referred to.

6.01.11 **Governing System:**

The engine shall be fitted with a speed control device, which will control the speed under all conditions of load.

6.01.12 The governor shall offer following features:

a) Engine should be provided with an adjustable governor capable of regulating engine speed within 5% of its rated speed under any condition of load between shut-off and maximum load conditions of the pumps. The governor shall be set to maintain rated pump speed at maximum pump load.

b) Engine shall be provided with an over speed shut- down device. It shall be arranged to shut-down the engine at a speed approximately 20% above rated engine speed and for manual reset, such that the automatic engine controller will continue to show an over speed signal until the device is manually reset to normal operating position (Vol.II, NFPA, 1978).

6.01.13 The governor shall be suitable for operation without external power supply.

6.01.14 **Fuel System**

The diesel engine will run on High Speed Diesel.

6.01.15 The engine shall be provided with fuel oil tank of 250 litres capacity. The fuel oil tank shall preferably be mounted near the engine. No fuel oil tank will be provided by the Employer.

6.01.16 The fuel oil tank shall be of welded steel constructed to relevant standards for mild steel drums. The outlet of the tank shall be above the inlet of fuel injection pump of the diesel engine to ensure adequate pressure at suction of injection pump.

6.01.17 The fuel oil tank shall be designed in such a way that the sludge and sediment settles down to the tank bottom and is not carried to the injection pump. A small sump shall be provided and fitted with drain plug to take out sludge/sediment and to drain oil. Adequate hand holes (greater than 80 mm size) shall be provided to facilitate maintenance.

6.01.18 Pipeline carrying fuel oil shall be gradually sloped from the tank to the injection pump. Any valve in the fuel feed pipe between the fuel tank and the engine shall be placed adjacent to the tank and it shall be locked in the open position. A filter shall be incorporated in this pipeline, in addition to other filters in the fuel oil system. Pipe joints shall not be soldered and plastic tubing shall not be used. Reinforced flexible pipes may also be used.

6.01.19 The complete fuel oil system shall be designed to avoid any air pocket in any part of the pipe work, fuel pump, sprayers/injectors, filter system etc. No air relief cock is permitted. However, where air relief is essential, plugs may be used.

6.01.20 A manual fuel pump shall be provided for priming and releasing of air from the fuel pipelines.

6.01.21 **Lubricating Oil System**

Automatic pressure lubrication shall be provided by a pump driven by the crank shaft, taking suction from a sump and delivering pressurised oil through cooler and fine mesh filters to a main supply header fitted in the bed plate casing. High pressure oil shall be supplied to the main and big end bearings, cam-shaft bearings, cam-shaft chain and gear drives, governor, auxiliary drive gears etc. Valve gear shall be lubricated at reduced pressure through a reducing valve and the cams by an oil bath.

6.01.22 **Cooling Water System**

Direct cooling or heat exchanger type cooling system shall be employed for the diesel engine. Water shall be tapped from the fire pump discharge. This water shall be led through duplex strainer, pressure breakdown orifice and then after passing through the engine, the water at the outlet shall be taken directly to the sump through an elevated funnel.

6.02.00 **Testing & Inspection**

6.02.01 The manufacturer shall conduct all tests required, to ensure that the equipment furnished conforms to the requirement of this sub-section and in compliance with requirements of applicable codes. The particulars of the proposed tests and the procedure for the tests shall be submitted to the Employer for approval before conducting the tests.

6.02.02 At manufacturer's works, tests shall be carried out during and after completion of manufacture of different component/parts and the assembly as applicable. Following tests shall be conducted.

6.02.03 Material analysis and testing.

6.02.04 Hydrostatic pressure testing of all pressure parts.

6.02.05 Static and dynamic balance tests of rotating parts at applicable over-speed and determination of vibration level.

6.02.06 MPI/DPT on machined parts of piston and cylinder.

6.02.07 Ultrasonic testing of crankshaft and connecting rod after heat treatment.

6.02.08 Dimensional check of close tolerance components like piston, cylinder bore etc.

6.02.09 Calibration tests of all fuel pumps, injectors, standard orifices, nozzles, instruments etc.

6.02.10 Over speed test of the assembly at 120% of rated speed.

6.02.11 Power run test.

6.02.12 Performance test of the diesel engine to determine its torque, power and specific fuel consumption as function of shaft speed. Performance test of the engine shall be carried for 12 hours out of which 1 hour at full load and one hour at 110% overload.

6.02.13 Measurement of vibration & noise.

(i) Measurement of vibration

The vibration shall be measured during full load test as well as during the overload test and limit shall be 100 microns.

(ii) Measurement of noise level

The equivalent 'A' weighted sound level measured at a distance of 1.5 M above floor level in elevation and 1.0 M horizontally from the base of the equipment, expressed in dB to a reference of 0.0002 microbar shall not exceed 93 dBA.

Above tests for vibration shall be repeated at site as pre-commissioning tests.

6.02.14 Adjustment of speed governor as per BS:5514.

6.02.15 Diesel engine shall be subjected to routine tests as per BS:5514.

7.00.00 **PIPING, VALVES AND SPECIALITIES**

This clause covers the design, manufacture, shop testing, erection, testing and commissioning of piping, valves and specialities.

7.02.00 **Scope**

The piping system which shall include but not be limited to the following:

7.02.01 Plain run of piping, bends, elbows, tees, branches, laterals, crosses, reducing unions, couplings, caps, expansion joints, flanges, blank flanges, thrust blocks, anchors, hangers, supports, saddles, shoes, vibration dampeners, sampling connections, hume pipes etc.

7.02.02 Gaskets, ring joints, backing rings, jointing material etc. as required. Also all welding electrodes and welding consumables including special ones, if any.

7.02.03 Instrument tapping connections, stubs etc.

7.02.04 Gate and globe valves to start/stop and regulate flow and swing check valves for one directional flow.

7.02.05 Basket strainers and Y-type strainers

7.02.06 Bolts, nuts, fasteners as required for interconnecting piping, valves and fittings as well as for terminal points. For pipe connections into Owner's R.C.C. works, Bidder will furnish all inserts.

7.02.07 Painting, anti-corrosive coatings etc. of pipes and equipment.

Adequate number of air release valves shall be provided at the highest points in the piping system to vent any trapped air in the system.

7.03.00 **Design**

7.03.01 Material of construction of various pipes shall be as follows :

(a) **Buried Pipes**

Mild steel black pipes as per ASTM A53 medium grade suitably lagged on the outside to prevent soil corrosion, as specified elsewhere.

(b) **Overground Pipes normally full of water**

Mild steel black pipes as per ASTM A53 medium grade.

(c) Overground pipes normally empty, but periodic charge of water and for detector line for HVW System**.**

Mild steel galvanised pipes as per ASTM A53 medium grade.

7.03.02 All fittings to be used in connection with steel pipe lines upto a size of 80 mm shall be as per ASTM A53 Mild steel tubulars and other wrought steel pipe fittings, Heavy grade. Fittings with sizes above 80 mm upto 150 mm shall be fabricated from ASTM A53 Heavy grade pipes or steel plates having thickness not less than those of ASTM A53 Heavy grade pipes. Fittings with sizes above 150 mm shall be fabricated as per ASTM A53 standard. All fitting used in GI piping shall be threaded type. Welding shall not be permitted on GI piping.

7.03.03 Pipe sizes shall not be less than the sizes indicated in the attached drawings.

7.03.04 For steel pipeline, welded construction should be adopted unless specified otherwise.

7.03.06 All piping system shall be capable of withstanding the maximum pressure arising from any condition of operation and testing including water hammer effects.

7.03.09 Gate/sluice valve shall be used for isolation of flow in pipe lines and **construction** shall be as per BS 5150. Valves shall be of rising spindle type and of PN 1.6 class

7.03.10 Gate Valves shall be provided with the following :

(a) Hand wheel.

(b) Position indicator.

(c) Locking facility (where necessary).

7.03.11 Gate valves shall be provided with back seating bush to facilitate gland removal during full open condition.

7.03.12 Globe valves shall be provided with contoured plug to facilitate regulation and control of flow. All other requirements should generally follow those of gate valve.

7.03.13 Non-return valves shall be swing check type. Valves will have a permanent "arrow" inscription on its body to indicate direction of flow of the fluid.

7.03.14 Whenever any valve is found to be so located that it cannot be approached manually from the nearest floor/gallery/platform hand wheel with floor stand or chain operator shall be provided for the same.

7.03.15 Valves below 50 mm size shall have screwed ends while those of 50 mm and higher sizes shall have flanged connections.

7.03.14 **Basket Strainer**

a) Basket strainers shall be of 30mesh and have the following materials of construction :

Body: Fabricated mild steel (Tested Quality). Strainer Wires: stainless steel (AISI : 316), 30 SWG, suitably reinforced.

b) Inside of basket body shall be protected by two (2) coats of heavy duty bitumastic paint.

c) Strainers shall be Simplex design. Suitable vent and drain connections with valves shall be provided.

d) Screen open area shall be at least 4 times pipe cross sectional area at inlet.

e) Pressure drop across strainer in clean condition shall not exceed 1.5 MWC at 410M3/hr (for 400kV substations) and 1 MWC at 273M3/hr flow (for 220kV & 132kV substations). Pressure drop test report of strainer of same design shall be furnished.

7.03.15 **Y-type On-line Strainer**

Body shall be constructed of mild steel (tested quality). Strainer wires shall be of stainless steel AISI:316, 30 SWG, 30 mesh.

Blowing arrangement shall be provided with removable plug at the outlet. Screen open area shall be atleast 4 times pipe cross-sectional area at inlet.

Pressure drop test report of strainer of same design shall be furnished.

7.03.16 **Hydrant Valve (Outdoor) and Indoor Hydrant Valves (Internal Landing Valves).**

The general arrangement of outdoor stand post assembly, consisting of a column pipe and a hydrant valve with a quick coupling end shall be as per TAC requirement.

Materials of construction shall be as follows or superior :

a) Column pipe M.S. ASTM A53 med. grade.

b) Hydrant Valve

i)	Body	Stainless steel**.**
ii)	Trim	Leaded tin bronze.
iii)	Hand Wheel	Cast Iron.
iv)	Washer, gasket, etc.	Rubber.
v)	Quick coupling connection	Leaded tin bronze
vi)	Spring	Phosphor Bronze.
vii)	Cap and chain	Leaded tin bronze

The general design of hydrant valve shall conform to relevant latest international standards.

7.03.17 **Hoses, Nozzles, Branch pipes and Hose boxes**

(a) Hose pipes shall be of reinforced rubber-lined canvas construction with nominal size of 63 MM (2 1/2") and lengths of 15 metre or 7.5 metre, as indicated elsewhere.

(b) Hosepipes shall be capable of withstanding an internal water pressure of not less than 35**.7** kg/cm2 without bursting. It must also withstand a working pressure of 8.5 kg/cm2 without undue leakage or sweating.

(c) Each hose shall be fitted with instantaneous spring lock type couplings at both ends. Hose shall be fixed to the coupling ends by copper rivets and the joint shall be reinforced by 1.5 mm galvanised mild steel wires and leather bands.

(d) Branch pipes shall be constructed of copper and have rings of leaded tin bronze at both ends. One end of the branch pipe will receive the quick coupling while the nozzles will be fixed to the other end.

(e) Nozzles shall be constructed of leaded tin bronze.

(f) Suitable spanners of approved design shall be provided in adequate numbers for easy assembly and dismantling of various components like branch pipes, nozzles, quick coupling ends etc.

(g) Hose pipes fitted with quick coupling ends, branch pipes, nozzles spanner etc. will be kept in a hose box, which will be located near point of use.

(h) All instantaneous couplings, as mentioned under clause Nos.3.03.19, 3.03.20 and 3.03.21 above shall be of identical design (both male and female) so that any one can be interchanged with another. One male, female combination shall get locked in by mere pushing of the two halves together but will provide leak tightness at a pressure of 8 kg/cm2 of water. Designs employing screwing or turning to have engagement shall not be accepted.

7.04.00 **Fabrication & Erection**

7.04.01 The contractor shall fabricate all the pipe work strictly in accordance with the related approved drawings.

7.04.02 **End Preparation**

(a) For steel pipes, end preparation for butt welding shall be done by machining.

(b) Socket weld end preparation shall be sawing/machining.

(c) For tees, laterals, mitre bends, and other irregular details cutting templates shall be used for accurate cut.

7.04.03 **Pipe Joints**

(a) In general, pipes having sizes over 25 mm shall be joined by butt welding. Pipes having 25 mm size or less shall be joined by socket welding/screwed connections. Galvanised pipes of all sizes shall have screwed joints. No welding shall be permitted on GI pipes. Screwed joints shall have tapered threads and shall be assured of leak tightness without using any sealing compound.

(b) Flanged joints shall be used for connections to vessels, equipment, flanged valves and also on suitable straight lengths of pipe line of strategic points to facilitate erection and subsequent maintenance work.

7.04.04 **Overground Piping**

(a) Piping to be laid overground shall be supported on pipe rack/supports. Rack/supports details shall have to be approved by Employer/Engineer.

(b) Surface of overground pipes shall be thoroughly cleaned of mill scale, rust etc. by wire brushing. Thereafter one (1) coat of **red oxide primer** shall be applied. Finally two (2) coats of synthetic enamel paint of approved colour shall be applied.

7.04.05 **Buried Pipe Lines**

(a) Pipes to be buried underground shall be provided with protection against soil corrosion by coating and wrapping with two coats of coal tar hot enamel paint and two wraps of reinforced fibre glass tissue. The total thickness of coating and wrapping shall not be less than 3 mm. Alternatively corrosion resistant tapes can also be used for protection of pipes against corrosion.

(b) For Coating and wrapping, holiday testing to be performed inline with latest ASTM standards.

(c) Buried pipelines shall be laid with the top of pipe one meter below ground level.

(d) At site, during erection, all coated and wrapped pipes shall be tested with an approved Holiday detector equipment with a positive signalling device to indicate any fault hole breaks or conductive particle in the protective coating.

7.05.00 **General Instruction for Piping Design and Construction**

7.05.01 While erecting field run pipes, the contractor shall check, the accessibility of valves, instrument tapping points, and maintain minimum headroom requirement and other necessary clearance from the adjoining work areas.

7.05.02 Modification of prefabricated pipes, if any, shall have to be carried out by the contractor at no extra charge to the Employer.

7.05.03 **Welding**

(i) Welding shall be done by qualified welders only.

(ii) Before welding, the ends shall be cleaned by wire brushing, filing or machine grinding. Each weld-run shall be cleaned of slag before the next run is deposited.

(iii) Welding at any joint shall be completed uninterrupted. If this cannot be followed for some reason, the weld shall be insulated for slow and uniform cooling.

(iv) Welding shall be done by manual oxyacetylene or manual shielded metal arc process. Automatic or semi-automatic welding processes may be done only with the specific approval of Employer/ Consultant.

(v) As far as possible welding shall be carried out in flat position. If not possible, welding shall be done in a position as close to flat position as possible.

(vi) No backing ring shall be used for circumferential butt welds.

(vii) Welding carried out in ambient temperature of 5°C or below shall be heat-treated.

(viii) Tack welding for the alignment of pipe joints shall be done only by qualified welders. Since tack welds form part of final welding, they shall be executed carefully and shall be free from defects. Defective welds shall be removed prior to the welding of joints.

Electrodes size for tack welding shall be selected depending upon the root opening.

(ix) Tacks should be equally spaced as follows **:**

for 65 NB and smaller pipes	:	2 tacks
for 80 NB to 300 NB pipes	:	4 tacks
for 350 NB and larger pipes	:	6 tacks

(x) Root run shall be made with respective electrodes/filler wires. The size of the electrodes/filler wires. The size of the electrodes shall not be greater than 3.25 mm (10 SWG) and should preferably be 2.3 mm (12 SWG). Welding shall be done with direct current values recommended by the electrode manufacturers.

(xi) Upward technique shall be adopted for welding pipes in horizontally fixed position. For pipes with wall thickness less than 3 mm, oxyacetylene welding is recommended.

(xii) The root run of butt joints shall be such as to achieve full penetration with the complete fusion of root edges. The weld projection shall not exceed 3 mm inside the pipe.

(xiii) On completion of each run craters, weld irregularities, slag etc. shall be removed by grinding or chipping.

(xiv) Fillet welds shall be made by shielded metal arc process regardless of thickness and class of piping. Electrode size shall not exceed 10 SWG. (3.25 mm). At least two runs shall be made on socket weld joints.

7.06.00 **Tests at Works**

7.06.01 **Pipes**

(i) Mechanical and chemical tests shall be performed as required in the codes/standards.

(ii) All pipes shall be subjected to hydrostatic tests as required in the codes/standards.

(iii) 10% spot Radiography test on welds of buried pipes shall be carried out as per ASME VIII.

7.06.02 **Valves**

(i) Mechanical and chemical tests shall be conducted on materials of the valve as required in the codes/standards.

(ii) All valves shall be tested hydrostatically for the seat as well as required in the code/standards for a period of ten minutes.

(iii) Air test shall be conducted to detect seat leakage.

(iv) Visual check on the valve and simple operational test in which the valve will be operated thrice from full open to full close condition.

(v) No repair work on CI valve body, bonnet or wedge shall be allowed.

7.06.03 **Strainers**

(i) Mechanical and chemical tests shall be conducted on materials of the strainer.

(ii) Strainers shall be subjected to a hydrostatic test pressure of 1.5 times the design pressure or 10 kg/cm2g whichever is higher for a period of one hour.

7.06.04 **Hydrant valves and Indoor Hydrant Valves (Internal Landing Valves)**

(i) The stand post assembly along with the hydrant valve (valve being open and outlet closed) shall be pressure tested at a hydrostatic pressure of 21 kg/cm2g to detect any leakage through defects of casting.

(ii) Flow test shall be conducted on the hydrant valves at a pressure of 7 kg/cm2g and the flow through the valve shall not be less than 900 litres/min.

(iii) Leak tightness test of the valve seat shall be conducted at a hydrostatic test pressure of 14 kg/cm2g.

7.06.05 **Hoses, Nozzles, Branch Pipes and Hose Boxes**

Reinforced rubber-lined canvas hoses shall be tested hydrostatically. Following tests shall be included as per relevant latest International standard.

a) Hydrostatic proof pressure test at 21.4 kgf/cm2g

b) Internal diameter

The branch pipe, coupling and nozzles shall be subjected to a hydrostatic test pressure of 21 kg/cm2g for a period of $2^{1}/_{2}$ minutes and shall not show any sign of leakage or sweating.

Dimensional checks shall be made on the hose boxes and nozzle spanners.

8.00.00 **AIR VESSELS**

8.01.00 Air vessels shall be designed and fabricated of mild steel as class-II vessels as per BS 5500 for a pressure of 14kg/cm^2 and shall be minimum 3 m^3 capacity.

8.02.00 Inside surface of the tank shall be protected by anti-corrosive paints/coatings/linings as required.

8.03.00 Outside surfaces of the vessels shall be provided with one (1) coat of red lead primer with two (2) coats of synthetic enamel paint of approved colour and characteristics.

8.04.00 **Tests & Inspection**

8.04.01 Air vessels shall be hydraulically tested at 21kg/cm2 for a period not less than one (1) hour.

8.04.02 All materials used for fabrication shall be of tested quality and test certificates shall be made available to the Owner.

8.04.03 Welding procedure and Welder's qualification tests will be carried out as per relevant Ienternational Standard.

8.04.04 NDE tests, which will include 100% Radiography on longitudinal seams and spot Radiography for circumferential seams, for pressure vessel will be carried out.

9.00.00 **HEAT DETECTORS/FIRE DETECTORS AND SPRAY NOZZLES**

9.00.01 **Intent of Specification**

This specification lays down the requirements of the smoke detectors, heat detectors and spray nozzles for use in various sub-systems of the fire protection system.

9.00.02 **Codes and Standards**

All equipment supplied shall conform to internationally accepted codes and standards.

9.01.00 **Heat Detectors**, **Quartzoid bulb type.** (Used in HVW spray system)

a) Heat detectors shall be of any approved and tested type. Fusible chemical pellet type heat detectors are however not acceptable.

b) Temperature rating of the heat detector shall be selected by the Bidder taking into consideration the environment in which the detectors shall operate. Minimum set point shall, however, be 79oC.

c) Heat detectors shall be guaranteed to function properly without any maintenance work for a period of not less than twenty five (25) years.

d) The heat detectors shall be mounted on a pipe network charged with water at suitable pressure. On receipt of heat from fire, the heat detector will release the water pressure from the network. This drop in water pressure will actuate the Deluge valve.

9.02.00 **HVW Spray Nozzles (Projectors)**

High velocity water spray system shall be designed and installed to discharge water in the form of a conical spray consisting of droplets of water travelling at high velocity which shall strike the burning surface with sufficient impact to ensure the formation of an emulsion. At the same time the spray shall efficiently cut off oxygen supply and provide sufficient cooling. Integral non-ferrous strainers shall be provided in the projectors ahead of the orifice to arrest higher size particle, which are not allowed to pass through the projectors.

9.03.00 **Fire Detectors (Used in fire detection and alarm system)**

9.03.01 Fire detectors shall be approved by FOC-London or similar international authorities.

9.03.02 Both smoke and heat type fire detectors shall be used. Bidder shall clearly indicate the mode of operation of detectors in his proposal.

9.03.03 The set point shall be selected after giving due consideration for ventilating air velocity and cable insulation.

9.03.04 Fire detectors shall be equipped with an integral L.E.D. so that it shall be possible to know which of the detectors has been operated. The detectors, which are to be placed in the space above the false ceiling or in the floor void shall not have the response indicators on the body but shall be provided with remote response indicators.

9.03.05 Approval from competent authority shall be made available for ionisation type smoke detectors. All required accessories shall also be included in the scope of supply.

9.03.06 Fire detectors shall be guaranteed to function properly without any maintenance work for a period of not less than ten (10) years.

10.00.00 **PORTABLE AND WHEEL/ TROLLEY MOUNTED FIRE EXTINGUISHERS**

10.00.01 This specification lays down the requirement regarding fire extinguishers of following types :

Portable fire extinguishers.

a) Pressurised water type.

b) Dry chemical powder type

c) Carbon Dioxide type

Wheel/ Trolley mounted fire extinguishers.

a) Mechanical foam type

10.00.02 All the extinguishers offered by the Bidder shall be of reputed make.

10.01.00 **Design and Construction**

10.01.01 All the portable extinguishers shall be of freestanding type and shall be capable of discharging freely and completely in upright position.

10.01.02 Each extinguisher shall have the instructions for operating the extinguishers on its body itself.

10.01.03 All extinguishers shall be supplied with initial charge and accessories as required.

10.01.04 Portable type extinguishers shall be provided with suitable clamps for mounting on walls or columns.

10.01.05 All extinguishers shall be painted with durable enamel paint of fire red colour conforming to relevant International Standards.

10.01.06 Pressurisation of water type fire extinguishers shall either be done by compressed air or by using gas cartridge. Both constant air pressure and the gas pressure type shall conform to their latest relevant International standards.

10.01.07 Dry chemical powder type portable extinguisher shall conform to its latest relevant International standards.

10.01.08 Carbon Dioxide type portable extinguisher and Carbon Dioxide type trolley mounted extinguisher shall conform to their latest relevant International standards.

10.01.09 Wheel/ trolley mounted fire extinguishers of 50 litre capacity Mechanical foam type shall conform to its **latest relevant International standards.**

10.02.00 **Tests and Inspection**

10.02.01 A performance demonstration test at site of five (5) percent or one (1) number whichever is higher, of the extinguishers shall be carried out by the Contractor. All consumable and replaceable items require for this test would be supplied by the Contractor without any extra cost to Employer.

10.02.02 Performance testing of extinguisher shall be in line of applicable International Standards. In case where no International Standard is applicable for a particular type of extinguisher, the method of testing shall be mutually discussed and agreed to before placement of order for the extinguishers.

10.03.00 **Painting**

Each fire extinguisher shall be painted with durable enamel paint of fire red colour conforming to relevant International Standards.

11.00.00 **INSTRUMENTS**

11.00.01 **Intent of Specification**

The requirements given in the sub-section shall be applicable to all the instruments being furnished under this specification.

11.00.02 All field mounted instruments shall be weather and dust tight, suitable for use under ambient conditions prevalent in the subject plant. All field mounted instruments shall be mounted in suitable locations where maximum accessibility for maintenance can be achieved.

11.01.00 **Local Instruments**

Pressure/ Differential Gauges & Switches.

11.01.01 The pressure sensing elements shall be continuous 'C' bourdon type.

11.01.02 The sensing elements for all gauges/switches shall be properly aged and factory tested to remove all residual stresses. They shall be able to withstand atleast twice the full scale pressure/vacuum without any damage or permanent deformation.

11.01.03 For all instruments, connection between the pressure sensing element and socket shall be braced or hard soldered.

11.01.04 Gauges shall be of 150 mm diameter dial with die-cast aluminium, stoved enamel black finish case, aluminium screwed ring and clear plastic crystal cover glass. Upper range pointer limit stop for all gauges shall be provided.

11.01.05 All gauges shall be with stainless steel bourdon having rotary geared stainless steel movements.

11.01.06 Weatherproof type construction shall be provided for all gauges. This type of construction shall be fully dust tight, drip tight, weather resistant and splash proof with anti-corrosive painting conforming to NEMA- 4.

11.01.07 All gauges shall have micrometer type zero adjuster.

11.01.08 Neoprene safety diaphragm shall be provided on the back of the instruments casing for pressure gauges of ranges 0-10 Kg/cm^2 and above.

11.01.09 Scales shall be concentric, white with black lettering and shall be in metric units.

11.01.10 Accuracy shall be $\pm$ 1.0 percent of full range or better.

11.01.11 Scale range shall be selected so that normal process pressure is approximately 75 percent of full scale reading. For pressure gauges and pressure switches, the range shall not be less than 0 -16 Kg/cm^2

11.01.12 All gauges shall have 1/2 inch NPT bottom connection.

11.01.13 All instruments shall conform to their **latest relevant International standards.**

11.01.14 All instruments shall be provided with 3 way gauge isolation valve or cock. Union nut, nipple and tail pipe shall be provided wherever required.

11.01.15 Switch element contact shall have two (2) NO and two (2) NC contacts rated for 230 Volts, 10 Amperes A.C. or 220 Volts, 5 Amperes D.C. Actuation set point shall be adjustable throughout the range. ON-OFF differential (difference between switch actuation and de-actuation pressures) shall be adjustable. Adjustable range shall be suitable for switch application.

11.01.16 Switches shall be sealed diaphragm, piston actuated type with snap action switch element. Diaphragm shall be of 316 SS.

11.01.18 Necessary accessories shall be furnished.

11.02.00 **Timers**

11.02.01 The timers shall be electro-mechanical type with adjustable delay on pick-up or reset as required.

11.02.02 Each timer shall have two pairs of contacts in required combination of NO and NC.

11.03.00 **Level Gauges/Indicator/Switches**

11.03.01 **Level Gauges**

i) Gauge glasses shall be used for local level indication wherever shown in the flow diagram.

ii) Gauge glasses, in general, shall be flag glass type with bolted cover. Body and cover material shall be of carbon steel with rubber lining.

iii) Level coverage shall be in accordance with operating requirements. Maximum length of a single gauge glass shall not exceed 1.4 M. Should a larger gauge glass be required, multiple gauges of preferably equal length shall be used with 50 mm overlap in visibility.

iv) Reflex type gauge glasses shall be used for colourless liquids and transparent type gauge glasses shall be used for all liquids having colour.

v) Each gauge glass shall be complete with a pair of offset valves. Valves shall have union bonnet, female union level connection, flanged tank connection, and vent and drain plug.

vi) Offset valves shall have corrosion resistant ball-check to prevent fluid loss in the event of gauge glass breakage. Valve body shall have a working pressure of 200 percent of the maximum static pressure at the maximum process fluid temperature. Valve body materials shall be of carbon steel with rubber lining.

11.03.02 **Level Indicators**

i) Float type mechanical level gauges with linear scale type indicator shall be offered for measuring level of tanks wherever shown in the flow diagram.

ii) AISI-316 stainless steel float, guide rope and tape shall be used. Housing shall be of mild steel painted with anti-corrosive painting.

iii) The scale indicator shall be provided at a suitable height for ease of reading.

iv) Accuracy shall be + 1% of scale range or better.

11.03.03 **Level Switches**

i) Level switches shall be of ball float operated magnetic type complete with cage.

ii) Materials of construction shall be suitable for process and ambient conditions. The float material shall be AISI-316 stainless steel.

iii) Actuating switches shall be either hermetically sealed mercury type or snap acting micro-switches. Actuation set point shall be adjustable. ON-OFF differential (difference between switch actuation and de-actuation levels) shall be adjustable. Adjustable range shall be suitable for switch application. All switches shall be repeatable within + 1.0 percent of liquid level change required to activate switch. Contacts shall be rated for 50 watts resistive at 230 V A.C. Number of contacts shall be two NO and two NC for each level switch.

11.04.00 **Solenoid Valves**

11.04.01 The body of the valves shall be Forged brass or stainless steel.

11.04.02 The coil shall be continuous duty, epoxy moulded type Class-F, suitable for high temperature operation.

11.04.03 The enclosure shall be watertight, dust-tight and shall conform to NEMA-4 Standard.

11.04.04 The valves shall be suitable for mounting in any position.

11.05.00 **Switches, Lamps, Meters Etc.**

All electrical components on the panel namely push buttons, switches, lamps, meters etc. shall meet the requirements of sub-section Electrical enclosed with the specification.

11.06.00 All local instruments shall be inspected by Employer/Consultant as per the agreed quality plan.

11.07.00 Makes of control panel and local instruments, accessories shall be as per Employer's approval.

12.00.00 **ELECTRIC MOTORS**

12.01.00 **General**

12.01.01 This clause covers the requirements of three phase squirrel cage induction motors and single-phase induction motors.

12.01.02 The motors to be furnished, erected and commissioned as covered under this specification shall be engineered, designed, manufactured, erected, tested as per the requirements specified herein. These requirements shall however be read along with the requirements of the respective driven equipment being supplied under the specification of which this specification forms a part.

12.01.03 The motor supplied under this specification shall conform to the standards specified in GTR.

12.01.04 Terminal point for all motors supplied under this specification shall be at the respective terminal boxes.

12.01.05 Materials and components not specifically stated in this specification but are necessary for satisfactory operation of the motor shall be deemed to be included in the scope of supply of this specification.

12.01.06 Notwithstanding anything stated in this motor specification, the motor has to satisfy the requirement of the mechanical system during normal and abnormal conditions. For this the motor manufacturer has to co-ordinate with the mechanical equipment supplier and shall ensure that the motor being offered meets the requirements.

12.02.00 **Codes & Standards**

12.02.21 The design, manufacture, installation and performance of motors shall conform to the provisions of pursuant Electricity Rules. Nothing in these specifications shall be construed to relieve the Contractor of his responsibility.

12.02.22 In case of contradiction between this specifications and IEC, the stipulations of this specification shall be treated as applicable.

12.02.23 National Electrical code for hazardous location and relevant NEMA standard shall also be applicable for motors located in hazardous location.

12.03.00 **Design Features**

12.03.01 **Rating and type**

(i) The induction motors shall be of squirrel cage type unless specified otherwise.

(ii) The motors shall be suitable for continuous duty in the specified ambient temperature.

(iii) The MCR KW rating of the motors for 50^{o}C ambient shall not be less than the power requirement imposed at the motor shaft by the driven equipment under the most onerous operation conditions as defined elsewhere, when the supply frequency is 51.5 Hz (and the motor is running at 103% of its rated speed).

(iv) Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously in the system having the following particulars :

a) Rated terminal voltage

From 0.2 to 200 KW 400V (3 Phase, solidly earthed)

Below 0.2 KW 230 V (1 Phase, solidly earthed)

Variation in voltage $\pm$ 6%.

b) Frequency 50 Hz $\pm$ 3%.

c) Any combination of (a) & (b)

12.03.02 Enclosure

Motors to be installed outdoor and semi-outdoor shall have hose proof enclosure equivalent to IP-55. For motors to be installed indoor, the enclosure shall be dust proof equivalent to IP-54.

12.03.03 **Cooling method**

Motors shall be TEFC (totally enclosed fan cooled) type.

12.03.04 **Starting requirements**

(i) **Induction motor**

a) All induction motors shall be suitable for full voltage direct on-line starting. These shall be capable of starting and accelerating to the rated speed alongwith the driven equipment without exceeding the acceptable winding temperature even when the supply voltage drops down to 80% of the rated voltage.

b) Motors shall be capable of withstanding the electro-dynamic stresses and heating imposed if it is started at a voltage of 110% of the rated value.

c) The starting current of the motor at rated voltage shall not exceed six (6) times the rated full load current subject to tolerance as given in IEC 60034.

d) Motors when started with the driven equipment imposing full starting torque under the supply voltage condition specified under Clause 12.03.01 (iv) (a) shall be capable of withstanding at least two successive starts with coasting to rest between starts and motor initially at the rated load operating temperature. The motors shall also be suitable for three equally spread starts per hour, the motor initially at a temperature not exceeding the rated operating temperature.

e) The locked rotor withstand time under hot condition at 110% of rated voltage shall be more than the starting time with the driven equipment at minimum permissible voltage (clause 12.03.04 (i) (a) by at least two seconds or 15% of the accelerating time whichever is greater. In case it is not possible to meet the above requirement the Bidder shall offer centrifugal type speed switch mounted on the motor shaft which shall remain closed for speeds lower than 20% and open for speeds above 20% of the rated speed. The speed switch shall be capable of withstanding 120% of the rated speed in either direction of rotation.

12.03.05 **Running requirements**

(i) When the motors are operating at extreme condition of voltage and frequency given under clause no.12.03.01 (iv) the maximum permissible temperature rise over the ambient temperature of 50oC shall be within the limits specified in IEC 60034 after adjustment due to increase ambient temperature specified herein.

(ii) The double amplitude of motor vibration shall be within the limits specified in IEC/International standards. Vibration shall also be within the limits specified by the relevant standard for the driven equipment when measured at the motor bearings.

(iii) All the induction motors shall be capable of running at 80% of rated voltage for a period of 5 minutes with rated load commencing from hot condition.

(iv) Induction motors shall be so designed as to be capable of withstanding the voltage and torque stresses developed due to the difference between the motor residual voltage and incoming supply voltage during fast changeover of buses. The necessary feature incorporated in the design to comply with this requirement shall be clearly indicated in the proposal.

(v) Motors shall be capable of developing the rated full load torque even when the supply voltage drops to 70% of rated voltage. Such operation is envisaged for a period of one second. The pull out torque of the induction motors to meet this requirement shall not be less than 205% of full load torque.

(vi) The motors shall be capable of withstanding for 10 seconds without stalling or abrupt change in speed (under gradual increase of torque) an excess torque of 60 percent of their rated torque, the voltage and frequency being maintained at their rated value.

(vii) Guaranteed performance of the motors shall be met with tolerances specified in respective standards.

12.04.00 **Construction Features**

12.04.01 **Stator**

(i) **Stator frame**

The stator frames and all external parts of the motors shall be rigid fabricated steel or of casting. They shall be suitably annealed to eliminate any residual stresses introduced during the process of fabrication and machining.

(ii) **Stator core**

The stator laminations shall be made from suitable grade magnetic sheet steel varnished on both sides. They shall be pressed and clamped adequately to reduce the core and teeth vibration to minimum.

(iii) **Insulation and winding**

All insulated winding conductor shall be of copper. The overall motor winding insulation for all 400 volts motors shall be of epoxy thermosetting type i.e., class 'F' but limited to class-B operating from temperature rise consideration. Other motors may be of conventional class-B type. The windings shall be suitable for successful operation in hot, humid, tropical climate with the ambient temperature of 50oC.

12.04.02 **Rotor**

(i) Rotors shall be so designed as to keep the combined critical speed with the driven equipment away from the running speed by atleast 20%.

(ii) Rotors shall also be designed to withstand 120% of the rated speed for 2 minutes in either direction of rotation.

12.04.03 **Terminal box leads**

(i) For motors of 400 Volts and below a single terminal box may be provided for power and accessories leads.

(ii) Terminal boxes shall be of weatherproof construction designed for outdoor service. To eliminate entry of dust and water, gaskets of neoprene or approved equivalent shall be provided at cover joints and between box and motor frame.

(iii) Terminal box shall be suitable for top and bottom entry of cables.

(iv) Unless otherwise approved, the terminal box shall be capable of being turned through 360o in steps in 90o.

(v) The terminals shall be complete with all accessories for connecting external cables. They shall be designed for the current carrying capacity and shall ensure ample phase to phase to ground clearances.

(vi) Suitable tinned brass compression type cable glands and cable lugs shall be supplied by the Contractor to match Employer's cable.

(vii) Terminal box for single core cable shall be of non- magnetic material.

(viii) Marking of all terminals shall be in accordance with IEC / International standard..

12.04.04 **Rating Plates**

(i) Rating plates shall be provided for all motors giving the details as called for in IEC 60034 (for three phase squirrel cage induction motors).

(ii) In addition to above, the rating plate shall indicate the following :

a) Temperature rise in oC under normal working conditions.

b) Phase sequence corresponding to the direction of rotation for the application.

c) Bearing identification number (in case of ball/ roller bearing) and recommended lubricants.

12.04.05 **Other Constructional Features**

(i) Two independent earthing points shall be provided on opposite sides of the motor for bolted connection of Employer's earthing conductor to be specified to the successful Bidder.

(ii) Motor weighing more than 25 kg. shall be provided with eyebolts, lugs or other means to facilitate lifting.

12.05.00 **Paint and Finish**

12.05.01 Motor external parts shall be finished and painted to produce a neat and durable surface, which would prevent rusting and corrosion. The equipment shall be thoroughly degreased, all sharp edges and scales removed and treated with one coat of primer and two coats of grey enamel paint.

12.05.02 Motor fans shall also be painted to withstand corrosion.

12.05.03 All fasteners used in the construction of the equipment shall be either of corrosion resistant material or heavy cadmium plated.

12.05.04 Current carrying fasteners shall be either of stainless steel or high tensile brass.

12.06.00 **Tests at Manufacturers Works**

12.06.01 Motors shall be subject to routine tests in accordance with IEC 60034.

12.06.02 In addition, the following tests shall also be carried out :

a) 20% over speed test for 2 minutes on all rotors.

b) Measurement of vibration.

c) Measurement of noise level.

d) Phase sequence and polarity checks relative to mechanical rotation.

12.06.03 **Tests after installation at site**

(i) After installation and commissioning at site, the motors alongwith the driven equipment shall be subject to tests to ascertain their conformity with the requirement of this specification and those of the driven equipment specification and the performance data quoted by the Bidder.

(ii) In case of non-conformity of the motor with these specifications and performance requirement, the Engineer may at his discretion reject or ask for necessary rectification/replacement as detailed in general Terms and Conditions of Contract (GCC) Volume-I.

13.00.00 **BATTERY & BATTERY CHARGERS**

This clause covers the design, performance, manufacturing, construction features and testing of Battery and Battery charger used primarily for starting the diesel engine driving the fire water pumps. Battery Chargers shall be housed in Diesel Engine Panel.

13.01.00 **General Information**

13.01.01 The equipment specified hereinafter are required for starting the diesel engines and other operation of the plant as required.

13.01.02 For each diesel engine there shall be two (2) sets of Battery and two (2) sets of Battery Charger.

13.01.03 The D.C. voltage shall be obtained normally after necessary rectification by battery charger. The Battery Charging system shall be capable of meeting the following requirements :

13.01.04 Float charging the Battery.

13.01.05 Boost Charging the Battery.

13.01.06 The battery shall be large enough to crank the engine **3** times without charging in between and without getting drained to an extent which will affect its life.

13.01.07 The Bidder shall indicate the battery voltage and battery capacity in Ampere- Hour at ten (10) hour discharge rate. The battery voltage at any time during operation shall not be less than the minimum voltage required for operation of the D.C. loads.

13.02.00 **General Design**

The Battery shall be located indoor

13.02.01 **Battery**

(i) The cells shall be lead-acid type. The Battery shall be automotive type.

(ii) The cells shall be sealed in type with anti-splash type vent plug.

(iii) The cell terminal posts shall be provided with connector bolts and nuts, effectively coated with lead to prevent corrosion. Lead or lead coated copper connectors shall be furnished to connect up cells of battery set.

(iv) Positive and Negative terminal posts shall be clearly and indelibly marked for easy identification.

(v) The electrolyte shall be of battery grade Sulphuric Acid. Water for storage batteries conforming to relevant standards shall be used in the preparation of the electrolyte.

13.02.02 **Battery Charger**

(i) The Bidder shall furnish the battery charging scheme complete with all necessary accessories such as transformers, switches, fuses, starters, contactors, diodes, ammeters, voltmeters and other devices as required for trouble free operation. All devices and equipment shall conform to relevant International Standard or shall be Superior to it.

(ii) The scheme of the battery charger shall be such that the battery can be charged automatically as well as manually.

(iii) The boost charger shall have sufficient capacity to restore a fully discharged Battery to a state of full charge in eight (8) hours with some spare margin over maximum charging rate. Suitable provision shall be kept so that, for a particular engine, any of the two (2) charger units can be used for charging any of the two (2) batteries.

(iv) The instruments, switches and lamps shall be flush/semi-flush mounted on the front panel. Name plate of approved type shall be provided for each of these equipment.

(v) The panel shall be complete with internal wiring and input-output terminal block. Terminal blocks shall be clip on type of suitable rating. All equipment and wire terminals shall be identified by symbols corresponding to applicable schematic/wiring diagram.

(vi) Space heaters of adequate capacity shall be provided to prevent moisture condensation in the panel.

13.03.00 **Testing**

13.03.01 The Battery Charger shall also be subjected to the following tests at manufacturer's works as per IEC 60146.

13.03.02 Insulation test.

13.03.03 Connection checking.

13.03.04 Measurement of voltage regulation.

13.03.05 Auxiliary of devices.

13.03.06 Alternating current measurement.

13.03.07 Performance test.

13.03.08 Temperature rise test.

13.03.09 Following acceptance tests shall be carried out in batteries as per IEC/International standard.

a) Marking and packing

b) Verification of dimensions

c) Test for capacity

d) Test for voltage during discharge

Battery and battery charger shall be checked for auto charging and providing sufficient power for three consecutive starting kicks to diesel engine within five minutes with A.C. supply switched off.

14.00.00 **CONTROL & ANNUNCIATION PANELS**

14.01.00 **Intent of Specification**

The following requirement shall be applicable to the control and annunciation panels furnished under these specifications.

14.02.00 **General Information**

14.02.01 The equipment specified herein are required for controlling, metering, monitoring and indication of electrical systems of the plant offered.

14.02.02 The selection and design of all the equipment shall be so as to ensure reliable and safe operation of the plant and shall be subjected to approval by the Employer.

14.02.03 The reference ambient temperature outside the panel shall be taken as 50oC and relative humidity 100%.

14.03.00 **Equipment to be Furnished**

Control & annunciation panels shall be furnished complete with all accessories and wiring for safe and trouble free operation of the plant. Details are included in sub-section General.

14.04.00 **Constructional Details**

14.04.01 The panel frames shall be fabricated using suitable mild steel structural sections or pressed and shaped cold-rolled sheet steel of thickness not less than 2.5 mm. Frames shall be enclosed in cold-rolled sheet steel of thickness not less than 1.6 mm. Stiffeners shall be provided wherever necessary.

14.04.02 Panels shall be of free standing type and shall be provided with hinged door with locking arrangement. The access doors, cutest and covers shall be equipped with neoprene/synthetic rubber gaskets (conforming to IEC 60149) all around and the latches sufficiently strong to hold them in alignment when closed. The panels to be installed outdoor or semi outdoor shall have a degree of protection of IP:55 and those installed indoor shall have a degree of protection of IP:52 as per IEC 60947.

14.04.03 If a panel consists of a number of panels, each panel should be mounted side by side and bolted together to form a compact unit, when two panels meet, the joints shall be smooth, close fittings and un-obstructive.

14.04.04 Removable eye bolt or lifting lugs shall be provided on all panels to facilitate easy lifting.

14.04.05 The heights of all operating equipment on the panel shall be between 800 mm to 1600 mm from the finished floor level. The proper supporting arrangement shall be provided by the Contractor.

14.04.06 Cable entries to the panel may be from bottom or top. The cable entry required will be intimated to the successful Bidder. A suitable removable gland plate of 3 mm thick shall be mounted not less than 200 mm above the floor level.

14.04.07 All equipment mounted on the front face of the panels shall be flush or semi-flush type. All equipment shall be so located that their terminal and adjustment are readily accessible for inspection or maintenance and their removal and replacement can be done without interruption of service to other equipment. The contractor shall submit the panel general arrangement drawings clearly bringing out internal mounting details, dimensions of equipment, clearance between the equipment and the edges of the panel, for approval.

14.05.00 **Name Plates and Labels**

14.05.01 Each panel shall be provided with prominent, engraved identification plates for all front mounted equipment. Panel identification name plate shall be provided at front and rear as required.

14.05.02 All name plates shall be of non-rusting metal or 3 ply lamicold, with white engraved lettering on black background. Inscription and lettering sizes shall be subjected to Employer's approval.

14.05.03 Suitable plastic sticker labels shall be provided for easy identification of all equipment located inside the panel. These labels shall be positioned so as to be clearly visible and shall give the device number, as mentioned in the wiring drawings.

14.06.00 **AC/DC Power Supply**

14.06.02 The Employer will provide one feeder each for AC and DC to the panel. The Contractor shall make for his own arrangements for providing these power supplies to different panels.

14.06.02 The Contractor shall provide suitable isolating switch fuse unit in the control panel for receiving the above incoming AC and DC supplies. Fuse and link shall be provided for isolating of individual circuit without disturbing other circuits.

14.07.00 **Wiring**

14.07.01 All inter panel wiring and connections between panels (if there is group of panels) including all bus wiring for AC & DC supplies shall be provided by the Contractor.

14.07.02 All internal wiring shall be carried out with 1100 V grade, single core, 1.5 square mm or larger stranded copper wires having colour-coded PVC insulation. CT circuits shall be wired with 2.5 square mm copper wires, otherwise similar to the above.

14.07.03 Extra-flexible wire shall be used for wiring to devices mounted on moving parts such as doors.

14.07.04 Spare contacts of auxiliary relays, timers and switches shall be wired out to the terminal blocks as required by the Employer/Engineer at the time of detailed engineering.

14.08.00 **Terminal Blocks**

14.08.01 Terminal Blocks shall be of 650V grade, rated for 10 Amps and in one-piece moulding. It shall be complete with insulating barriers, clip-on-type terminals, and identification strips. Marking on terminal strip shall correspond to the terminal numbering on wiring diagrams. It shall be similar to 'Elmex-Standard' type terminals.

14.08.02 Terminal blocks shall be arranged with at least 100 mm clearance between two sets of terminal block.

14.08.03 The terminal blocks shall have at least 20% spare terminals.

14.09.00 **Grounding**

A continuous copper bus 25 x 3 mm size shall be provided along the bottom of the panel structure. It shall run continuously throughout the length of the panel and shall have provision at both ends for connection to the station grounding grid (25 x 6 mm MS Flat).

14.10.00 **Space Heater and Lighting**

14.10.01 Space heaters shall be provided in the panels for preventing harmful moisture condensation.

14.10.02 The space heaters shall be suitable for continuous operation on 230V AC, 50 Hz, single phase supply and shall be automatically controlled by thermostat. Necessary isolating switches and fuses shall also be provided.

14.10.03 Free standing panel shall have a 230V AC, plug point and a fluorescent light operated by door switch.

14.11.00 **Control and Selector Switches**

14.11.01 Control and selector switches shall be of rotary type, with escutcheon plates clearly marked to show the function and positions.

14.11.02 Control/selector switches shall be spring return or stay put type as per the requirements. Handles of control/selector switches shall be black in colour. Shape and type of handles shall be to the approval of the Employer.

14.11.03 The contact ratings shall be at least the following :

i)	Make and carry continuously	10 Amp.
ii)	Breaking current at 240V DC	1Amp. (Inductive)
iii)	Breaking current at 240V DC	5 Amp. at 0.3 p.f. lagging

14.12.00 **Push Buttons**

14.12.01 Push buttons shall be spring return, push to actuate type and rated to continuously carry and break 10A at 230V AC and 0.5A (Inductive) at 220V DC. The push buttons shall have at least 1 NO and 1 NC contact. All contact faces shall be of silver or silver alloy.

14.12.02 All push buttons shall be provided with integral escutcheon plates marked with its function.

14.12.03 The colour of buttons shall be as follows :

Green For motor START, Breaker CLOSE, Valve/ damper OPEN.

Red For motor TRIP, Breaker OPEN, Valve/ damper CLOSE.

Black For all annunciation functions, overload reset and miscellaneous.

14.12.04 Red push buttons shall always be located to the left of green push buttons. In case of clinker grinder etc. the push buttons would be black-red-green from left to right.

14.13.00 **Indicating Lamps**

14.13.01 Indicating lamps shall be of the panel mounting, filament type and of low-watt consumption. Lamps shall be provided with series resistors preferably built-in- the lamps assembly. The lamps shall have escutcheon plates marked with its function, wherever necessary.

14.13.02 Lamp shall have translucent lamp covers of the following colours :

Red for motor OFF, Valve/damper OPEN, Breaker CLOSED.

Green for motor ON, Valve/damper CLOSED, Breaker OPEN.

White for motor AUTO-TRIP.

Blue for all healthy conditions (e.g. control supply, lub oil pressure and also for spring charged).

Amber for all ALARM conditions (e.g. pressure low, over load and also for 'service' and 'Test' position indication).

14.13.03 Bulbs and lamps covers shall be easily replaceable from the front of the panel.

14.13.04 Indicating lamps should be located directly above the associated push button/control switches. Red lamps shall variably be located to the right of the green lamp. In case a white lamp is also provided, it shall be placed between the red and green lamps. Blue and amber lamps should normally be located above the red and green lamps.

14.14.00 **Fuses**

14.14.01 All fuses shall be of HRC cartridge plug-in-type and shall be of suitable rating, depending upon circuit requirements.

14.14.02 All fuses shall be mounted on fuse carriers, which shall be mounted on fuse-bases.

14.15.00 **Contactors**

14.15.01 Contactors shall be of air break, electromagnetic type rated as per requirement.

14.15.02 Operating coils of AC contactors shall be of 230V AC or 220V DC as required. AC contactors shall operate satisfactorily between 85% to 110% of the rated voltage. The Contactor shall not drop out at 70% of the rated voltage.

14.15.03 DC contactors shall have a coil voltage of 220V DC and shall be suitable for satisfactory continuous operation at 80% to 110% of the rated voltage.

14.16.00 **Relays and Timers**

14.16.01 All auxiliary relays & timers shall be of proven design and of reputed make. Contacts of relays and timers shall be of solid silver or silver cadmium oxide or solid silver faced. Timers shall have the provision to adjust the delay on pick-up or reset as required.

14.16.02 All relays and timers shall have at least two NO and two NC contacts.

14.16.03 All relays and timers shall be suitable for 230V AC and 220V DC as required. DC relays shall operate satisfactorily between 70% to 110% and AC relays shall be suitable for voltage variation between 80% to 110%.

14.17.00 **Indication Instruments**

14.17.01 All indicating and integrating meters shall be flush mounted on panel front. The instruments shall be of at least 96 mm square size with 90 degree scales and shall have an accuracy class of 2.0 or better. The covers and cases of instruments and meters shall provide a dust and vermin proof construction.

14.17.02 All instruments shall be compensated for temperature errors and factory calibrated to directly read the primary quantities. Means shall be provided for zero adjustment removing or dismantling the instruments.

14.17.03 All instruments shall have white dials with black numerals and lettering. Black knife edge pointer with parallax free dials will be preferred.

14.17.04 Ammeters provided on motor feeders shall have a compressed scale at the upper current region to cover the starting current.

14.18.00 **Annunciation System**

14.18.01 The annunciation system shall be complete with all necessary relays, flashers and other accessories required for the proper operation of the equipment and shall be completely solid state. The control circuit shall be mounted on plug-in type glass epoxy printed circuit boards. Audible alarms for the system shall be mounted inside the panel. One set of acknowledge, test and reset push buttons shall be mounted on the panel.

14.18.02 Indications shall be engraved on Acrylic inscription plate window and shall be visible clearly when the indication lamp is lighted (black letters on white background). Each window shall be provided with two lamps.

14.18.03 Audible hooter shall sound when a trouble contact operates and shall continue to sound until the acknowledge button is pressed. In addition to the hooters provided on annunciation panels, a hooter shall be provided outside FFPH which shall sound in any fire alarm condition.

14.18.04 Indication lamps shall flash when trouble contact operates and shall continue flashing until acknowledge button is pressed.

14.18.05 After acknowledge button is pressed, the hooter and flashing shall stop but the indication lamp shall remain lighted.

14.18.06 After trouble is cleared indication lamps shall be ready and shall go off only when reset.

14.18.07 Silencing the hooter in conjunction with one trouble contact shall not stop and hooter sounding if another trouble contact operates.

14.18.08 When test button is pressed, all lamps shall flash and hooter shall sound.

14.18.09 Annunciator systems shall operate on 220V DC Systems.

14.18.10 The annunciation system shall include alarm for AC control system failure (working on DC supply), DC supply failure (working on AC supply) and test facilities for these alarms.

14.18.11 List of annunciations required on the panels has been listed elsewhere. The Contractor shall also provide additional annunciations if desired by the Employer/Engineer during Vendor drawing review stage and for such additional annunciations no extra charges shall be claimed by the Contractor, if the number of such additions are within 10% of the number stipulated in this specification.

14.18.12 20% spare windows shall be provided on the panel.

14.19.00 **Painting**

14.19.01 **Painting procedure adopted shall conform to requirements given in GTR**. The paint thickness shall not be less than **60** microns. Finished parts shall be coated by peelable compound by spraying method to protect the finished surface from scratches, grease, dirt and oily spots during testing, transportation handling and erection.

14.20.00 **Tests**

14.20.01 following tests/inspection shall be carried out by the Contractor in the presence of Employer's representative:

(A) Factory Tests

1. Compliance with approved drawings, data and specification.

2. Visual check for workmanship.

3. Wiring continuity and functional checks.

4. Calibration of instruments, relays and metres wherever required by inspector.

5. HV test

6. Insulation resistance measurement before and after HV test.

(B) Inspection/Testing at site :

1. IR test before and after HV test

2. HV Test

3. Functional Testing.

(C)

1. The Fire detection and annunciation panel shall be subjected to functional tests.

2. The Annunciation System shall be routine tested

CHAPTER 12: POWER AND CONTROL CABLE

1.0 POWER & CONTROL CABLES [FOR WORKING VOLTAGES UP TO AND INCLUDING 1100 V]

CRITERIA FOR SELECTION OF POWER & CONTROL CABLES

1.1.1. Aluminium conductor XLPE insulated armoured cables shall be used for main power supply purpose from LT Aux. Transformers to control room, between distribution boards and for supply for colony lighting from control room.

1.1.2 Aluminium conductor PVC insulated armoured power cables shall be used for various other applications in switchyard area/control room except for control/protection purposes.

1.1.3 For all control/protection/instrumentation purposes PVC insulated armoured control cables of minimum 2.5 sq. mm. size with stranded Copper conductors shall be used.

1.1.4 Employer has standardised the sizes of power cables for various feeders. Bidders are to estimate the quantity of cables and quote accordingly. The sizes of power cables to be used per feeder in different application shall be as follows:

S.No.	From	To	Cable size	Cable type
1.	Main Switch Board	LT Transformer	2-1C X 630 mm^2 per phase 1-1C X 630 mm^2 for neutral	XLPE
2.	Main Switch Board	AC Distribution Board	2-3½C X 300 mm^2	XLPE
3.	Main Switch Board	Oil Filtration Unit	1-3½C X 300 mm^2	XLPE
4.	Main Switch Board	Colony Lighting	1-3½C X 300 mm^2	XLPE
5.	Main Switch Board	HVW pump LCP	1-3½C X 300 mm^2	XLPE
6.	Main Switch Board	Main Lighting distribution board	2-3½C X 300 mm^2	XLPE
7.	AC Distribution Board	D.G. Set AMF Panel	2-3½C X 300 mm^2	XLPE
8.	AC Distribution Board	Emergency Lighting distribution board	1-3½C X 70 mm^2	PVC
9.	AC Distribution	ICT MB	1-3½C X 70 mm^2	PVC

	Board			
10.	AC Distribution Board	Bay MB	1-3½C X 70 mm^2	PVC
11.	Bay MB	AC Kiosk	1- 3 ½ x 70 mm^2	PVC
12.	AC Distribution Board	Battery Charger	1-3½C X 70 mm^2	PVC
13.	DCDB	Battery	2-1C X 150 mm^2	PVC
14.	DCDB	Battery Charger	2-1C X 150 mm^2	PVC
15.	DCDB	Protection/PLCC panel	1-4C X 16 mm^2	PVC
16.	Main Lighting DB	Lighting panels(Indoor)	1-3½C X 35 mm^2	PVC
17.	Main Lighting DB	Lighting panels (outdoor)	1-3½C X 70 mm^2	PVC
18.	Main Lighting DB	Receptacles (Indoor)	1-3½C X 35 mm^2	PVC
19.	Main Lighting DB	Receptacles (Outdoor)	1-3½C X 70 mm^2	PVC
20.	Lighting Panel	Sub lighting panels	1-4C X 16 mm^2	PVC
21.	Lighting Panel	Street Lighting Poles	1-4C X 16 mm^2	PVC
22.	Lighting Panel/ Sub lighting panels	Lighting Fixtures (Outdoor)	1-2C X 6 mm^2	PVC
23.	Bay MB	Equipments	1-4C X 16 mm^2 /1-4C X 6 mm^2 /1-2C X 6 mm^2	PVC

1.1.5 Bidder may offer sizes other than the sizes specified in clause 1.1.4. In such case and for other application where sizes of cables have not been indicated in the specification, sizing of power cables shall be done keeping in view continuous current, voltage drop & short-circuit consideration of the system. Relevant calculations shall be submitted by bidder during detailed engineering for purchaser's approval.

1.1.6 Cables shall be laid as per relevant IEC/International Standards.

1.1.7 While preparing cable schedules for control/protection purpose following shall be ensured:

1.1.7.1 Separate cables shall be used for AC & DC.

1.1.7.2 Separate cables shall be used for DC1 & DC2.

1.1.8 For different cores of CT & CVT separate cable shall be used

1.1.9 Atleast one (1) cores shall be kept as spare in each copper control cable of 4C, 5C or 7C size whereas minimum no. of spare cores shall be two (2) for control cables of 10 core or higher size.

1.1.10 For control cabling, including CT/VT circuits, 2.5 sq.mm. size copper cables shall be used per connection. However, if required from voltage drop/VA burden consideration additional cores shall be used. Further for potential circuits of energy meters separate connections by 2 cores of 2.5 sq.mm. size shall be provided.

1.1.11 Technical data requirement sheets for cable sizes are being enclosed at Annex-I.

1.2. TECHNICAL REQUIREMENTS

1.2.1. General

1.2.1.1. The cables shall be suitable for laying in racks, ducts, trenches, conduits and underground buried installation with uncontrolled back fill and chances of flooding by water.

1.2.1.2. They shall be designed to withstand all mechanical, electrical and thermal stresses under steady state and transient operating conditions. The XLPE /PVC insulated L.T. power cables of sizes 240 sq. mm. and above shall withstand without damage a 3 phase fault current of at least 45 kA for at least 0.12 second, with an initial peak of 105 kA in one of the phases at rated conductor temperature (70 degC for PVC insulated cables and 90 degC for XLPE insulated cables). The armour for these power cables shall be capable of carrying 45 kA for at least 0.12 seconds without exceeding the maximum allowable temperature of PVC outer sheath.

1.2.1.3. The XLPE insulated cables shall be capable of withstanding a conductor temperature of 250°C during a short circuit without any damage. The PVC insulated cables shall be capable of withstanding a conductor temperature of 160°C during a short circuit.

1.2.1.4. The Aluminium/Copper wires used for manufacturing the cables shall be true circular in shape before stranding and shall be uniformly good quality, free from defects. All Aluminium used in the cables for conductors shall be of H2 grade. In case of single core cables armours shall be of H4 grade Aluminium.

1.2.1.5. The fillers and inner sheath shall be of non-hygroscopic, fire retardant material, shall be softer than insulation and outer sheath shall be suitable for the operating temperature of the cable.

1.2.1.6. Progressive sequential marking of the length of cable in metres at every one metre shall be provided on the outer sheath of all cables.

1.2.1.7. Strip wire armouring method shall not be accepted for any of the cables. For control cables only round wire armouring shall be used.

1.2.1.8. The cables shall have outer sheath of a material with an oxygen index of not less than 29 and a temperature index of not less than 250°C.

1.2.1.9. All the cables shall pass fire resistance test as per IEC: 60502 (Part-I)

1.2.1.10. The normal current rating of all PVC insulated cables shall be as per IEC: 60502.

1.2.1.11. Repaired cables shall not be accepted.

1.2.1.12. Allowable tolerance on the overall diameter of the cables shall be plus or minus 2 mm.

1.2.2. **XLPE Power Cables**

1.2.2.1. The XLPE insulated cables shall be of FR type, C1 category conforming to IEC: 60502 (Part-I) and its amendments read alongwith this specification. The conductor shall be stranded aluminium circular/sector shaped and compacted. In multicore cables, the core shall be identified by red, yellow, blue and black coloured strips or colouring of insulation. A distinct inner sheath shall be provided in all multicore cables. For XLPE cables, the inner sheath shall be of extruded PVC to type ST-2 of IEC: 60502. When armouring is specified for single core cables, the same shall consist of aluminium wires/strips. The outer sheath shall be extruded PVC to Type ST-2 of IEC: 60502 for all XLPE cables.

1.2.3. **PVC Power Cables**

1.2.3.1. The PVC (70°C) insulated power cables shall be of FR type, C1 category, conforming to IEC: 60502 (Part-I) and its amendments read alongwith this specification and shall be suitable for a steady conductor temperature of 70°C. The conductor shall be stranded aluminium. The Insulation shall be extruded PVC to type-A of IEC: 60502. A distinct inner sheath shall be provided in all multicore cables. For multicore armoured cables, the inner sheath shall be of extruded PVC. The outer sheath shall be extruded PVC to Type ST-1 of IEC: 60502 for all cables.

1.2.4. **PVC Control Cables**

1.2.4.1. The PVC ***(70°C) insulated*** control cables shall be of FR type C1 category conforming to IEC: 60502 (Part-1) and its amendments, read alongwith this specification. The conductor shall be stranded copper. The insulation shall be extruded PVC to type A of IEC: 60502. A distinct inner sheath shall be provided in all cables whether armoured or not. The over sheath shall be extruded PVC to type ST-1 of IEC: 60502 and shall be grey in colour .

1.2.4.2. Cores shall be identified as per IEC: 60502 (Part-1) for the cables up to five (5) cores and for cables with more than five (5) cores the identification of cores shall be done by printing legible Hindu Arabic Numerals on all cores as per IEC: 60502 (Part-1).

2.0 HV POWER CABLES[FOR WORKING VOLTAGES FROM 3.3 kV AND INCLUDING 33 kV]

1.3. **HV POWER CABLE FOR AUXILIARY POWER SUPPLY**

1.4. The HV cable of 1Cx185 mm2 (Aluminium Conductor) or 1Cx120mm2 (Copper Conductor) of voltage class as specified for 630 kVA LT transformer for interconnecting 630kVA LT transformer to the NEA feeder shall be, XLPE insulated, armoured cable conforming to IEC: 60502 (Part-2). Terminating accessories shall conform to IEC 61442-1997/IEC60502-4 1998.

1.5. Bidder may offer sizes other than the sizes specified in clause 2.1. In such case sizing of power cables shall be done keeping in view continuous current, voltage drop & short-circuit consideration of the system. Relevant calculations shall be submitted by bidder during detailed engineering for purchaser's approval.

1.6. **Constructional Requirements**

Cable shall have compacted circular Aluminium conductor, Conductor screened with extruded semi conducting compound, XLPE insulated, insulation screened with extruded semi conducting compound, armoured with non-magnetic material, followed by extruded PVC outer sheath (Type ST-2), with FR properties.

2.4 Progressive sequential marking of the length of cable in metres at every one metre shall be provided on the outer sheath of the cable.

2.5 The cables shall have outer sheath of a material with an Oxygen Index of not less than 29 and a Temperature index of not less than 250°C.

2.6 Allowable tolerance on the overall diameter of the cables shall be plus or minus 2 mm.

3.0 CABLE DRUMS

3.1 Cables shall be supplied in returnable wooden or steel drums of heavy construction. Wooden drum shall be properly seasoned sound and free from defects. Wood preservative shall be applied to the entire drum.

3.2 Standard lengths for each size of power and control cables shall be 500/1000 meters. The cable length per drum shall be subject to a tolerance of plus or minus 5% of the standard drum length. The owner shall have the option of rejecting cable drums with shorter lengths. Maximum, One (1) number non standard lengths of cable size(s) may be supplied in drums for completion of project.

3.3 A layer of water proof paper shall be applied to the surface of the drums and over the outer most cable layer.

3.4 A clear space of at least 40 mm shall be left between the cables and the lagging.

3.5 Each drums shall carry the manufacturer's name, the purchaser's name, address and contract number and type, size and length of the cable, net and gross weight stencilled on both sides of drum. A tag containing the 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.

3.6 Packing shall be sturdy and adequate to protect the cables, from any injury due to mishandling or other conditions encountered during transportation, handling and storage. Both cable ends shall be sealed with PVC/Rubber caps so as to eliminate ingress of water during transportation and erection.

4.0 TYPE TESTS

4.1 All cables shall conform to all type, routine and acceptance tests listed in the relevant IEC.

4.2 XLPE INSULATED POWER CABLES (For working voltages up to and including 1100V)

4.2.1 Following type tests (on one size in a contract) as per IEC: 60502 (Part 1) including its amendments shall be carried out as a part of acceptance tests on XLPE insulated power cables for working voltages up to and including 1100 V:

a) Physical tests for insulation
   i) Hot set test
   ii) Shrinkage test
b) Physical tests for outer sheath
   i) Shrinkage test
   ii) Hot deformation
   iii) Heat shock test
   iv) Thermal stability

4.2.2 Contractor shall submit type test reports as per clause no. 9.2 of Technical Specification, Chapter 2: GTR for the following tests-

a) Water absorption (gravimetric) test.
b) Ageing in air oven
c) Loss of mass in air oven
d) Short time current test on power cables of sizes 240 sqmm and above on
   i) Conductors.
   ii) Armours.
e) Test for armouring wires/strips.
f) Oxygen and Temperature Index test.
g) Flammability test.

4.3 PVC INSULATED POWER & CONTROL CABLES (For working voltages up to and including 1100V)-

4.3.1 Following type tests (on one size in a contract) as per IEC: 60502 (Part 1) including its amendments shall be carried out as a part of acceptance tests on PVC insulated power & control cables for working voltages up to and including 1100 V:

a) Physical tests for insulation and outer sheath
   i) Shrinkage test
   ii) Hot deformation
   iii) Heat shock test
   iv) Thermal stability
b) High voltage test.

4.3.2 Contractor shall submit type test reports as per clause no. 9.2 of Technical Specification, Chapter 2: GTR for the following-

a) High voltage test.
b) Ageing in air oven.
c) Loss of mass in air oven.
d) Short time current test on power cables of sizes 240 sqmm and above on

i) Conductors.
ii) Armours.

e) Test for armouring wires/strips.

f) Oxygen and Temperature Index test.

g) Flammability test.

4.4 XLPE INSULATED HV POWER CABLES(For working voltages from 3.3 kV and including 33 kV)

4.4.1 Contractor shall submit type test reports as per clause no. 9.2 of Technical Specification, Chapter 2: GTR for XLPE insulated HV power cables (as per IEC: 60502 Part-2).

4.5 Terminating/jointing accessories as per IEC 60840:1999/ IEC62067

CHAPTER 13: BATTERY & BATTERY CHARGER

1.1. GENERAL TECHNICAL REQUIREMENTS

1.1.1. All materials/components used in battery chargers and batteries shall be free from flaws and defects and shall conform to the relevant Indian/IEC standards and good engineering practice.

1.1.2. DC System shall consist of two (2) float-cum-boost chargers and two(2) battery sets for each of 220V and 48 V systems respectively. The standard scheme drawing is enclosed with this specification.

1.1.3. Bidder shall select number of cells, float and Boost voltage to achieve following system requirement:

System Voltage	Maximum Voltage during Float operation	Minimum voltage available when no charger working and battery fully discharged upto 1.85V per cell.	Minimum Nos of cell
220 Volt	242 Volt	198 Volt	107
110 Volt	121 Volt	99 Volt	54
48 Volt	52.8 Volt	43.2 Volt	23

Bidder shall furnish calculation in support of battery sizing, selection of number of cells, float and Boost voltages during detailed engineering for Owners acceptance.
Battery sizing calculations shall be done as per IEEE- 485 on the basis of following duty cycle:

	Load	Duration	Type Of Loads
220V DC System	Continuous Load	3 hours	Relays, IEDs, Station HMIs, spring charging, Isolator interlocking load, Miscellaneous permanently connected loads etc.
	Emergency Load	1 hour	Substation emergency lighting loads.
	Momentary Load	1 minute	Breaker closing, Tripping loads (taking simultaneous occurrence as per system)
48V DC System	Continuous Load	3 hours	Continuous load associated with PLCs.(when speech is not working)
	Momentary Load	15 minute	Loads associated with PLCs (when speech is working)

1.2. Battery

1.2.1. Type

The DC Batteries shall be VRLA (Valve Regulated Lead-Acid) type and shall be Normal Discharge type. These shall be suitable for a long life under continuous float operations and occasional discharges. Air-conditioning shall be provided in Battery room the requirement of which has been specified elsewhere in the Technical Specification. The 220 V DC system is unearth and 48 V DC system is + ve earth system.

1.2.2. Constructional Requirements

The design of battery shall be as per field proven practices. Partial plating of cells is not permitted. Paralleling of cells externally for enhancement of capacity is not permitted. Protective transparent front covers with each module shall be provided to prevent accidental contact with live module/electrical connections.

1.2.3. Containers

The container material shall have chemical and electro-chemical compatibility and shall be acid resistant. The material shall meet all the requirements of VRLA batteries and be consistent with the life of battery. The container shall be fire retardant and shall have an Oxygen Index of at least 28 %. The porosity of the container shall be such as not to allow any gases to escape except from the regulation valve. The tensile strength of the material of the container shall be such as to handle the internal cell pressure of the cells in the worst working condition. Cell shall not show any deformity or bulge on the sides under all working conditions. The container shall be capable of withstanding the rigours of transport, storage and handling. The containers shall be enclosed in a steel tray.

1.2.4. Cell Covers

The cell covers shall be made of suitable material compatible with the container material and permanently fixed with the container. It shall be capable to withstand internal pressure without bulging or cracking. It shall also be fire retardant. Fixing of Pressure Regulation Valve & terminal posts in the cover shall be such that the seepage of electrolyte, gas escapes and entry of electro-static spark are prevented.

1.2.5. Separators

The separators used in manufacturing of battery cells, shall be of glass mat or synthetic material having high acid absorption capability, resistant to sulphuric acid and good insulating properties. The design of separators shall ensure that there is no misalignment during normal operation and handling.

1.2.6. Pressure Regulation Valve

Each cell shall be provided with a pressure regulation valve. The valve shall be self re-sealable and flame retardant. The valve unit shall be such that it cannot be opened without a proper tool. The valve shall be capable to withstand the internal cell pressure specified by the manufacturer.

1.2.7. Terminal Posts

Both the +ve and –ve terminals of the cells shall be capable of proper termination and shall ensure its consistency with the life of the battery. The surface of the terminal post extending above the cell cover including bolt hole shall be coated with an acid resistant and corrosion retarding material. Terminal posts or any other metal part which is in contact with the electrolyte shall be made of the same alloy as that of the plates or of a proven material that does not have any harmful effect on cell performance. Both +ve and –ve posts shall be clearly and unambiguously identifiable.

1.2.8. Connectors, Nuts & Bolts, Heat Shrinkable Sleeves

Where it is not possible to bolt the cell terminals directly to assemble a battery, separate non-corroding lead or copper connectors of suitable size shall be provided to enable connection of the cells. Copper connections shall be suitably lead coated to withstand corrosion due to sulphuric acid at a very high rate of charge or discharge.

Nuts and bolts for connecting the cells shall be made of copper, brass or stainless steel. Copper or brass nuts and bolts shall be effectively lead coated to prevent corrosion. Stainless steel bolts and nuts can be used without lead coating.

All inter cell connectors shall be protected with heat shrinkable silicon sleeves for reducing the environmental impact including a corrosive environment.

1.2.9. Flame Arrestors

Each cell shall be equipped with a Flame Arrestor to defuse the Hydrogen gas escaped during charge and discharge. Material of the flame arrestor shall not affect the performance of the cell.

1.2.10. Battery Bank Stand

All batteries shall be mounted in a suitable metallic stand/frame. The frame shall be properly painted with the acid resistant paint. The suitable insulation shall be provided between stand/frame and floor to avoid the grounding of the frame/stand.

1.2.11. Capacity Requirements

When the battery is discharged at 10 hour rate, it shall deliver 80% of C (rated capacity, corrected at 27º Celsius) before any of the cells in the battery bank reaches 1.85V/cell.

The battery shall be capable of being recharged from the fully exhausted condition (1.75V/cell) within 10 hrs up to 90% state of charge. All the cells in a battery shall be designed for continuous float operation at the specified float voltage throughout the life.

The capacity (corrected at 27ºCelcius) shall also not be less than C and not more than 120% of C before any cell in the battery bank reaches 1.75V/cell. The battery voltage shall not be less than the following values, when a fully charged battery is put to discharge at C/10 rate:

(a) After Six minutes of discharge : 1.98V/cell
(b) After Six hours of discharge : 1.92V/cell
(c) After 8 hours of discharge : 1.85V/cell
(d) After 10 hours of discharge : 1.75V/cell

Loss in capacity during storage at an average ambient temperature of 35º Celcius for a period of 6 months shall not be more than 60% and the cell/battery shall achieve 85% of its rated capacity within 3 charge/discharge cycles and full rated capacity within 5 cycles, after the storage period of 6 months. Voltage of each cell in the battery set shall be within 0.05V of the average voltage throughout the storage period. Ampere hour efficiency shall be better than 90% and watt hour efficiency shall be better than 80%.

1.2.12. **Expected Battery Life**

The battery shall be capable of giving 1200 or more charge/discharge cycles at 80% Depth of discharge (DOD) at an average temperature of 27º Celsius. DOD (Depth of Discharge) is defined as the ratio of the quantity of electricity (in Ampere-hour) removed from a cell or battery on discharge to its rated capacity. The battery sets shall have a minimum expected life of 20 years at float operation.

1.2.13. **Routine Maintenance of Battery system**

For routine maintenance of battery system, the contractor shall supply 1 set of following tools:

a) Torque wrench.

b) Cell test voltmeter(-3-0-+3) volts with least count of 0.01Volt.

1.2.14. **Type Test of Battery**

1.2.14.1. Contractor shall submit type test reports of following tests as per IEC 60896-21 & IEC 60896-22, 2004. The type test reports shall be submitted in accordance with the requirements stipulated in clause no. 9.2 of Technical Specification, Chapter 2: GTR except that the requirement of tests having been conducted within last five years as mentioned therein shall not be applicable.

S.No.	Description of test
1.	Gas emission
2.	High current tolerance
3.	Short circuit current and d.c. internal resistance
4.	Protection against internal ignition from external spark sources
5.	Protection against ground short propensity
6.	Content & durability of required markings
7.	Material identification
8.	Valve operation
9.	Flammability rating of materials
10.	Intercell connector performance
11.	Discharge Capacity
12.	Charge retention during storage
13.	Float service with daily discharges for reliable mains power
14.	Recharge behaviour
15.	Service life at an operating temperature of 40^0 C for brief duration exposure time.
16.	Impact of a stress temperature of 60^0 C for brief duration exposure

	time with 3 h rate discharge test.
17.	Abusive over-discharge
18.	Thermal runaway sensitivity
19.	Low temperature sensitivity
20.	Dimensional sensitivity at elevated internal pressure and temperature
21.	Stability against mechanical abuse of units during installation

Tests shall be conducted in accordance with IEC 60896-21 & IEC 60896-22, 2004

1.2.14.2. **List of Factory & Site Tests for Battery**

Sl. No.	Test	Factory Tests	Site Tests
1.	Physical Verification		√
2.	C/10 Capacity test on the cell	√	
3.	8 Hrs. Charge and 15 minutes discharge test at full rated load		√

1.2.15. **Installation and commissioning**

1.2.15.1. Manufacturer of Battery shall supervise the installation and commissioning and perform commissioning tests as recommended in O&M manual / or relevant standards. All necessary instruments, material, tools and tackles required for installation, testing at site and commissioning are to be arranged by Battery manufacturer/ Contractor

1.2.16. Contractor shall be submitted following documents for approval:

a) Data sheet as per Annexure-I
b) GA of cell and layout drawing
c) Discharge Data for 10 Hour, 8 Hour, 3 Hour, 2 Hour, 1 Hour, 15 Minutes and One Minute indicating capacity factors for end cell voltage of 1.75 V & 1.85 V.
d) Temperature correction factors
e) Installation and commissioning Instructions
f) O & M Manual

1.3. Battery Charger

The DC system for 220 V DC is unearthed and for 48 V DC is +ve earthed. The Battery Chargers as well as their automatic regulators shall be of static type and shall be compatible with offered VRLA batteries. All battery chargers shall be capable of continuous operation at the respective rated load in float charging mode, i.e. Float charging the associated Lead-Acid Batteries at 2.13 to 2.27 Volts per cell while supplying the DC load. The chargers shall also be capable of Boost charging the associated DC Battery at 2.28 to 2.32 volts per cell at the desired rate.

Charger shall regulate the float/boost voltage in case of prescribed temperature rise of battery as per manufacturer's recommendation to avoid thermal runaway. Necessary temperature sensors shall be provided in mid location of battery banks and shall be wired up to the respective charger for feedback control. The manufacturer shall demonstrate this feature during testing of each charger.

1.3.1. All Battery Chargers shall be provided with facility for both automatic and manual control of output voltage and current. A selector switch shall be provided for selecting the mode of output voltage/current control, whether automatic or manual. When on automatic control mode during Float charging, the Charger output voltage shall remain within $\pm$1% of the set value, for AC input voltage variation of $\pm$10%, frequency variation of $\pm$2.5%, a combined voltage and frequency variation of $\pm$10%, and a DC load variation from zero to full load.

1.3.2. All battery chargers shall have a constant voltage characteristics throughout the range (from zero to full load) at the floating value of the voltage so as to keep the battery fully charged but without harmful overcharge.

1.3.3. All chargers shall have load limiters having drooping characteristic, which shall cause, when the voltage control is in automatic mode, a gradual lowering of the output voltage when the DC load current exceeds the Load limiter setting of the Charger. The Load-limiter characteristics shall be such that any sustained overload or short circuit in DC System shall not damage the Charger, nor shall it cause blowing of any of the Charger fuses. The Charger shall not trip on overload or external short circuit.

1.3.4. Uniform and step less adjustments of voltage setting (in both manual and automatic modes) shall be provided on the front of the Charger panel covering the entire float charging output range specified. Step less adjustments of the Load-limiter setting shall also be possible from 80% to 100% of the rated output current for Charging mode.

1.3.5. During Boost Charging, the Battery Charger shall operate on constant current mode (when automatic regulator is in service). It shall be possible to adjust the Boost charging current continuously over a range of 50 to 100% of the rated output current for Boost charging mode.

1.3.6. The Charger output voltage shall automatically go on rising, when it is operating on Boost mode, as the Battery charges up. For limiting the output voltage of the Charger, a potentiometer shall be provided on the front of the panel, whereby it shall be possible to set the upper limit of this voltage any where in the output range specified for Boost Charging mode.

1.3.7. The Charger manufacturer may offer an arrangement in which the voltage setting device for Float charging mode is also used as output voltage limit setting device for Boost charging mode and the Load-limiter of Float charging mode is used as current setting device in boost charging mode.

1.3.8. Suitable filter circuits shall be provided in all the chargers to limit the ripple content (Peak to Peak) in the output voltage to 1%, irrespective of the DC load level, when they are not connected to a Battery.

1.3.9. **MCCB**

All Battery Chargers shall have 2 Nos. MCCBs on the input side to receive cables from two sources. Mechanical interlock should be provided such that only one shall be closed at a time. It shall be of P2 duty and suitable for continuous duty. MCCB's should have auxiliary contacts for annunciation.

1.3.10. **Rectifier Transformer**

The rectifier transformer shall be continuously rated, dry air cooled (A.N) and of class F insulation type. The rating of the rectifier transformer shall have 10% overload capacity.

1.3.11. **Rectifier Assembly**

The rectifier assembly shall be fully/half controlled bridge type and shall be designed to meet the duty as required by the respective Charger. The rectifier shall be provided with heat sink having their own heat dissipation arrangements with natural air cooling. Necessary surge protection devices and rectifier type fast acting HRC fuses shall be provided in each arm of the rectifier connections.

1.3.12. **Instruments**

One AC voltmeter and one AC ammeter alongwith selector switches shall be provided for all chargers. One DC voltmeter and DC ammeter (with shunt) shall be provided for all Chargers. The instruments shall be flush type, dust proof and moisture resistant. The instruments shall have easily accessible means for zero adjustment. The instruments shall be of 1.5 accuracy class. In addition to the above a centre zero voltmeter with selector switch shall also be provided for 220 V chargers for testing purpose.

1.3.13. **Air Break Switches**

One DC output switch shall be provided in all chargers. They shall be air break type suitable for 500 volts AC/ 250 DC. The contacts of the switches shall open and close with a snap action. The operating handle of the switch shall be fully insulated from circuit. `ON' and `OFF' position on the switch shall be clearly indicated. Rating of switches shall be suitable for their continuous load. Alternatively, MCCB's of suitable ratings shall also acceptable in place of Air Break Switch.

1.3.14. **Fuses**

All fuses shall be HRC Link type. Fuses shall be mounted on fuse carriers which are in turn mounted on fuse bases. Wherever it is not possible to mount fuses on carriers, fuses shall be directly mounted on plug-in type base. In such case one insulated fuse pulling handle shall be supplied for each charger. Fuse rating shall be chosen by the Bidder depending on the circuit requirement. All fuses in the chargers shall be monitored. Fuse failure annunciation shall be provided on the failure of any fuse.

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1.3.15. **Blocking Diode**

Blocking diode shall be provided in the positive pole of the output circuit of each charger to prevent current flow from the DC Battery into the Charger.

1.3.16. **Annunciation System**

Audio-visual indications through bright LEDs shall be provided in all Chargers for the following abnormalities:

a) AC power failure
b) Rectifier/chargers fuse blown.
c) Over voltage across the battery when boost charging.
d) Abnormal voltage (High/Low)
e) Any other annunciation if required.

Potential free NO Contacts of above abnormal conditions shall also be provided for common remote indication "CHARGER TROUBLE" in Owner's Control Board. Indication for charger in float mode and boost mode through indication lamps shall be provided for chargers. A potential free contact for float/boost mode shall be provided for external interlocks.

1.3.17. **Name Plates and Marking**

The name plates shall be white with black engraved letters. On top of each Charger, on front as well as rear sides, larger and bold name plates shall be provided to identify the Charger. Name plates with full and clear inscriptions shall also be provided on and inside of the panels for identification of the various equipments and ease of operation and maintenance.

1.3.18. **Charger Construction**

The Chargers shall be indoor, floor-mounted, self-supporting sheet metal enclosed cubicle type. The Contractor shall supply all necessary base frames, anchor bolts and hardware. The Chargers shall be fabricated from 2.0mm cold rolled sheet steel and shall have folded type of construction. Removable gland plates for all cables and lugs for power cables shall be supplied by the Contractor. The lugs for power cables shall be made of electrolytic copper with tin coat. Power cable sizes shall be advised to the Contractor at a later date for provision of suitable lugs and drilling of gland plates. The Charger shall be tropicalised and vermin proof. Ventilation louvers, if provided shall be backed with screens. All doors and covers shall be fitted with synthetic rubber gaskets. The chargers shall have hinged double leaf doors provided on front and on back-side for adequate access to the Charger's internals. All the charger cubicle doors shall be properly earthed. The degree of protection of Charger enclosure shall be at least IP-42 as per IEC:- 60947 Part 1.

1.3.18.1. All indicating instruments, control switches and indicating lamps shall be mounted on the front side of the Charger.

1.3.18.2. Each Charger shall be furnished completely wired upto power cable lugs and terminal blocks and ready for external connections. The control wiring shall be carried out with PVC insulated, 1.5 sq.mm. stranded copper wires. Control terminals shall be suitable for connecting two wires, with 2.5 sq.mm stranded copper conductors. All terminals shall be numbered for ease of connections and identification. Each wire shall bear a ferrule or tag on each end for identification. At least 20% spare terminals shall be provided for control circuits.

1.3.18.3. The insulation of all circuits, except the low voltage electronic circuits shall withstand test voltage of 2 KV AC for one minute. An air clearance of at least ten (10) mm shall be maintained throughout for such circuits, right up to the terminal lugs. Whenever this clearance is not available, the live parts shall be insulated or shrouded.

1.3.19. **Painting**

All sheet steel work shall be pre-treated, in tanks, in accordance with IEC/International Standards. Degreasing shall be done by alkaline cleaning. Rust and scale shall be removed by pickling with acid. After pickling, the parts shall be washed in running water. Then these shall be rinsed in slightly alkaline hot water and dried. The phosphate coating shall be in accordance with IEC/International Standards. Welding shall not be done after phosphating. The phosphating surfaces shall be rinsed and passivated prior to application of stoved lead oxide primer coating. After primer application, two coats of finishing synthetic enamel paint of shade-692 (smoke grey) shall be applied, unless required otherwise by the Owner. The inside of the chargers shall be glossy white. Each coat of finishing synthetic enamel paint shall be properly staved. The paint thickness shall not be less than fifty (50) microns.

1.3.20. **TESTS**

1.3.20.1. Battery chargers shall conform to all type tests as per relevant International Standard. Performance test on the Chargers as per Specification shall also be carried out on each Charger as per specification. Rectifier transformer shall conform to all type tests specified in IEC: 60146 and short circuit test as per IEC:60076. Following type tests shall be carried out for compliance of specification requirements:

i) Voltage regulation test
ii) Load limiter characteristics test
iii) Efficiency tests
iv) High voltage tests
v) Temperature rise test
vi) Short circuit test at no load and full load at rated voltage for sustained short-circuit.
vii) Degree of protection test
viii) Measurement of ripple by oscilloscope.
ix) Temperature compensation feature demonstration

1.3.20.2. The Contractor may be required to demonstrate to the OWNER that the Chargers conform to the specification particularly regarding continuous rating, ripple free output, voltage regulation and load limiting characteristic, before despatch as well as after installation at site. At site the following tests shall be carried out :

i) Insulation resistance test
ii) Checking of proper annunciation system operation.

1.3.20.3. If a Charger fails to meet the specified requirements, the Contractor shall replace the same with appropriate Charger without affecting the commissioning schedule of the Sub-station, and without any extra cost to the OWNER.

1.3.20.4. The Contractor shall present for inspection, the type and routine test certificates for the following components whenever required by the OWNER.

(i) Switches.
(ii) Relays/ MCCBs
(iii) Instruments.
(iv) DC fuses.
(v) SCR.
(vi) Diodes.
(vii) Condensers.
(viii) Potentiometers.
(ix) Semiconductor
(x) Annunciator.
(xi) Control wiring
(xii) Push buttons and contactors.

Makes of above equipment shall be subject to Owner's approval.

Annexure-I

BATTERY SYSTEM DATA SHEETS

SN	Description of Data	Unit	220 V/ 110 V	48 V
1	General Data			
a)	Battery Type:			
	Grid alloy: Pure lead(Pb), lead calcium (Pb-Ca),lead antimony (Pb-Sb), or lead selenium (Pb-Se) or other pl. specify			
	Cell type: Absorbed glass mat or gel cell or other please specify			
	Seller's type number			
	Number of positive plates per cell			
b)	Does each battery and battery [rack]/ [cabinet] meet the seismic requirements	[Yes] [No]		
c)	Manufacturer's Designed Life of Battery	Yrs		
d)	Recommended Battery Charger Data:			
	Floating voltage range	V		
	Boost charge	V		
	Current rating	Amps.		
	Recharge time	hr		
e)	Heat Released During:			
	Discharge duty cycle	Watt		
	Float charge	Watt		
	Boost Charge	Watt		
f)	Maximum Amount of Hydrogen Gas Evolved			
	During Battery-Boost Charge (2.33 V per cell) at Maximum Battery Temperature	(Litre /h)		
	Hydrogen Gas Evolution at Float	(Litre /h)		
g)	Time Battery may be Stored Without a Freshening Charge	months		
h)	Temperature Compensation Provided			

SN	Description of Data	Unit	220 V/ 110 V		48 V	
	and its Details					
2	Physical Description.					
a)	Battery Cell:					
	Size (L x W x H)	mm				
	Weight	Kg				
	Volume of electrolyte gal	L				
	Jar cover material					
	Jar container material					
	Separator material					
	Retainer material					
	Limiting-oxygen index (LOI)					
b)	Battery [Rack] [Cabinet]:					
	Outline or catalog number					
	Quantity of [racks][cabinets] for the battery					
	Description (tier or step type)					
c)	Total Net Weight of Battery Including [Racks] [Cabinets]	kg				
d)	Total Shipping Weight of Each Battery Jar and Associated Equipment	kg				
e)	Connectors:					
	Intercell:					
	Type					
	Material					
	No. per connection					
	Inter-[Tier] [Step]:					
	Type					
	Material					
	No. per connection					
	Terminal Detail:					
	Type					
	Material					
f)	Terminal Lugs for Power Cable:					
g)	Torque Data:		**Initial Torque Value**	**Re-torque Value**	**Initial Torque Value**	**Re-torque Value**
	Intercell Connectors					
	Inter-[Tier] [Step]:					

SN	Description of Data	Unit	220 V/ 110 V	48 V
3	Performance Data.			
	Battery String Designation No. [1] [ ]			
	Float Voltage Without Boost	V/cell		
	Float Voltage With Boost	V/cell		
	Boost Charge Voltage	V/cell		
	Recommended Frequency of Boost Charge			
	Recommended Duration of Boost Charge			
	Open-Circuit Voltage	V/cell		
	Short-Circuit Current at Battery Terminals at Float Voltage at (27°C):			
	Battery Discharge Characteristics	A or A /positive plate		
	Guaranteed Amp-Hour Capacity (at the 10-hr rate) to Specified Final Voltage	AH		
	One-minute	A/cell		
	Fifteen-minute	A/cell		
	One-hour	A/cell		
	Two-hour	A/cell		
	Three-hour	A/cell		
	Eight-hour	A/cell		
	Ten-hour	A/cell		
4	Required operating environment.			
	Battery Room Ambient Temperature Range	(°C to °C)		
	Battery Room Ambient Design Temperature	°C		
	Battery Room Minimum/Maximum Design Temperature	(°C to °C)		
	Maximum temperature at which battery can be stored	°C		

CHAPTER 14: SWITCHYARD ERECTION

1.0 GENERAL

The detailed Scope of work includes design, engineering , manufacture, testing at works, supply at site basis, insurance, handling, storage erection, testing and commissioning of various items and works as details herein.

This Chapter covers the description of the following items.

A. Supply of

- String insulators and hardware
- AAC / ACSR conductor
- Galvanised Steel Earthwire
- Aluminium Tubular Bus Bars
- Spacers
- Bus post insulators
- Earthing & Earthing materials
- Lightning protection materials
- Cabling material
- Other items

B. Erection Of all items

1.1 String Insulators & Hardware

The insulators for suspension and tension strings shall conform to IEC-60383 and long rod insulators shall conform to IEC-60433. Insulator hardware shall conform to equivalent international standard. Composite long rod insulator shall conform to IEC: 61109.

A. Tension Insulator String

Sl. No.	System Voltage	Type
1.	400kV, 220kV & 132kV (for all substations)	Composite Long Rod Polymer with 31mm/kV Creepage

B. Suspension Insulator String

Sl. No.	System Voltage	Type
1.	400kV, 220kV & 132kV (for all substations)	Composite Long Rod Polymer with 31mm/kV Creepage

1.1.1 Construction Features

1.1.1.1 For porcelain insulators

a) Suspension and tension insulators shall be wet process porcelain with ball and socket connection. Insulators shall be interchangeable and shall be suitable for forming either suspension or tension strings. Each insulator shall have rated strength markings on porcelain printed and applied before firing.

b) Porcelain used in insulator manufacture shall be homogeneous, free from laminations, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.

c) Glazing of the porcelain shall be uniform brown colour, free from blisters, burrs and other similar defects.

1.1.1.2 **For glass insulators**

It shall be made of toughened glass. Glass used for the shells shall be sound, free from defects, flows bubbles, inclusions, etc and be of uniform toughness over its entire surface. All exposed glass surfaces shall be smooth.

1.1.1.3 When operating at normal rated voltage there shall be no electric discharge between conductor and insulator which would cause corrosion or injury to conductors or insulators by the formation of substances due to chemical ion. No radio interference shall be caused when operating at normal rated voltage.

1.1.1.4 The design of the insulator shall be such that stresses due to expansion and contrion in any part of the insulator shall not lead to deterioration. All ferrous parts shall be hot dip galvanized. The zinc used for galvanizing shall be of grade Zn-99.95. The zinc coating shall be uniform, adherent, smooth, reasonably bright, continuous and free from imperfections such as flux, ash, rust stains bulky white deposits and blisters.

1.1.1.5 Bidder shall make available data on all the essential features of design including the method of assembly of discs and metal parts, number of discs per insulator string insulators, the manner in which mechanical stresses are transmitted through discs to adjacent parts, provision for meeting expansion stresses, results of corona and thermal shock tests, recommended working strength and any special design or arrangement employed to increase life under service conditions.

1.1.1.6 Clamps for insulator strings and Corona Control rings shall be of aluminium alloy as stipulated for clamps and connectors.

1.1.1.7 Insulator hardware shall be of forged steel. Malleable cast iron shall not be accepted except for insulator disc cap. The surface of hardware must be clean, smooth, without cuts, abrasion or projections. No part shall be subjected to excessive localized pressure. The metal parts shall not produce any noise generating corona under operating conditions.

1.1.1.8 The tension Insulator hardware assembly shall be designed for minimum 12000 kg tensile load. Earth wire tension clamp shall be designed for minimum 1000 kg tensile load with a factor of safety of two (2).

1.1.1.9 The tension string assemblies shall be supplied alongwith suitable turn buckle. Sag compensation springs if required may also be provided.

1.1.1.10 All hardware shall be bolted type.

1.2 Long Rod Porcelain Insulators

1.2.1 As an alternative to disc insulator, Bidder can offer long rod porcelain insulators strings, with suitable hardware. The combination should be suitable for application specified and should offer the identical/equivalent parameters as would be available from insulator string comprising disc insulators and hardware combination.

1.2.2 All constructional features specified at Clause 1.1.1 of this Chapter shall also apply to the long rod insulator string.

1.3 **Tests**

In accordance with the stipulations of the specification, the suspension and tension strings, insulator and hardware shall be subjected to the following type tests, acceptance tests and routine tests:

1.3.1 **Type Tests on Insulator Strings:** The test reports for following type tests shall be submitted for approval as per clause 9.0 of Chapter 2 - GTR.

a) Power frequency voltage withstand test with corona control rings under wet condition as per IEC- 60383.

b) Lightning Impulse voltage withstand test with corona control rings under dry condition as per IEC-60383

c) Voltage distribution test (Dry)

The voltage across each insulator unit shall be measured by sphere gap method. The result obtained shall be converted into percentage. The voltage across any disc shall not exceed 13% for 220KV suspension and tension insulator strings, 20% and 22% for 132KV suspension and tension insulator strings respectively.

e) Corona Extinction Voltage test (Dry) :- (As per Chapter 2-GTR)

The sample assembly when subjected to power frequency voltage shall have a corona extinction voltage of not less than mentioned at IEC. There shall be no evidence of Corona on any part of the sample. The atmospheric condition during testing shall be recorded and the test results shall be accordingly corrected with suitable correction for as stipulated in IEC 60383.

f) RIV Test (Dry)

Under the conditions as specified under (e) above the insulator string alongwith complete hardware fittings shall have a radio interference voltage level below 1000 microvolts at 1 MHz when subjected to 50 Hz AC line to ground voltage of 156kV for 220kV string under dry conditions. The test procedure shall be in accordance with IEC 60437.

g) Mechanical strength test

The complete insulator string alongwith its hardware fitting excluding arcing horn, corona control ring, grading ring, tension/suspension clamps shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. The load shall be held for five minutes and then removed. After removal of the load, the string components shall not show any visual deformation and it shall be possible to dismantle them by hand. Hand tools may be used to remove cotter pins and loosen the nuts initially. The string shall then be reassembled and loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified minimum UTS and held for one minute. No failure should occur during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

1.3.2 Type Tests on Insulators

Type test report for Thermal Mechanical Performance tests as per IEC - 60575, Clause 3 / IEC: 61109, clause 5.1 (for composite long rod insulators) shall be submitted for approval as per clause 9.2 of Chapter 2 - GTR.

1.3.3 Acceptance Tests for Insulators:

a) Visual examination as per IEC-60383/ IEC-61109 clause no. 7.2 (for composite long rod insulators).

b) Verification of Dimensions as per IEC- 60383.

c) Temperature cycle test as per IEC- 60383.

d) Puncture Test as per IEC-60383 (Applicable only for porcelain insulators).

e) Galvanizing Test as per IEC- 60383.

f) Mechanical performance test as per IEC-60575 Cl. 4 / IEC-61109 clause no. 7.2 (for composite long rod insulators).

g) Test on locking device for ball and socket coupling as per IEC-60372(2).

h) Porosity test as per IEC- 60383 (Applicable only for porcelain insulators).

i) Thermal shock test as per IEC-60383 (Applicable only for glass insulators)

1.3.4 **Acceptance Test on Hardware Fitting**

a) Visual Examination as per relevant international standard.

b) Verification of Dimensions as per relevant international standard.
c) Galvanising/Electroplating tests as per relevant international standard.
d) Slip strength test as per relevant international standard.
e) Shore hardness test for the Elastometer (if applicable as per the value guaranteed by the Bidder).

f) Mechanical strength test for each component (including corona control rings and arcing horns).

The load shall be so applied that the component is stressed in the same way as it would be in ual service and the procedure as given in 1.2.13.1 (g) above should be followed.

g) Test on locking devices for ball and socket coupling as per IEC -60372(2).

1.3.5 **Routine Test on Insulator**

a) Visual Inspection as per IEC-60383

b) Mechanical Routine Test as per IEC-60383

c) Electrical Routine Test as per IEC-60383

1.3.6 **Routine Test on hardware Fittings**

a) Visual examination as per IEC-61109 (for composite long rod insulators).

b) Mechanical strength Test as per IEC-61109 (for composite long rod insulators).

1.3.7 **Test during manufacture on all Components as applicable on insulator**

a) Chemical analysis of zinc used for galvanising:

Samples taken from the zinc ingot shall be chemically analyzed. The purity of zinc shall not be less than 99.95%.

b) Chemical Analysis, mechanical hardness tests and magnetic particle inspection for malleable casting:

The chemical analysis, hardness tests and magnetic particle inspection for malleable casting will be as per the internationally recognized procedures for these tests. The sampling will be based on heat number and heat treatment batch. The details regarding tests will be as discussed and mutually agreed to by the Contractor and Owner in Quality Assurance Program.

1.3.8 Test during manufacture on all components as applicable on hardware fittings:

a) Chemical analysis of zinc used for galvanising:

Samples taken from the zinc ingot shall be chemically analyzed. The purity of zinc shall not be less than 99.95%

b) Chemical analysis, hardness tests and magnetic particle for forgings:

The chemical analysis, hardness tests and magnetic particle inspection for forgings will be as per the internationally recognized procedures for these tests. The sampling will be based on heat number and heat treatment batch. The details regarding tests will be as discussed and mutually agreed to by the Contractor and Owner in Quality Assurance Programme.

c) Chemical analysis and mechanical hardness tests and magnetic particle inspection for fabricated hardware:

The chemical analysis, hardness tests and magnetic particle inspection for fabricated hardware will be as per the internationally recognized procedures for these tests. The sampling will be based on heat number and heat treatment batch. The details regarding tests will be as discussed and mutually agreed to by the Contractor and Owner in Quality Assurance programme.

1.4 **Parameters**

1.4.1 **Disc Insulators**

Sl. No.	Description	For 400/220/132kV
a)	Type of insulators	Anti Fog type
b)	Size of insulator units (mm)	255x145 or 280x145
c)	Electro mechanical strength	120 kN
d)	Creepage distance of individual insulator units (minimum and as required to meet total creepage distance)	430 mm
e)	Markings	
i)	For Porcelain insulators	Markings on porcelain
ii)	For toughened glass insulators	Markings shall be done on initial parts
f)	Power frequency puncture withstand voltage	1.3 times the usual wet flashover voltage

*Long rod porcelain/composite insulators should conform to equivalent electrical and mechanical parameters.

1.4.2 INSULATOR STRING

SN	Description	400kV	220kV	132kV
a)	Power frequency withstand voltage of the complete string with corona control ring (wet) – KV rms	680	460	275
b)	Lightning impulse withstand Voltage of string with corona control rings (dry) - kVp	± 1550	± 1050	± 650
c)	Switching surge withstand voltage of string with corona control rings (wet) - kVp	± 1050	NA	NA
d)	Minimum corona extinction voltage level of string with Corona Control rings (dry) - kV rms	320	156	NA
e)	Maximum RIV level in micro volts of string with Corona Control rings at 320 kV (rms) for 400 kV string and 156 kV for 220 kV string across300 Ohms resistor at 1 MHz	1000	1000	NA
f)	Minimum total creepage distance of the insulator string (mm)	10500	6125	3625
g)	Total no. of discs per strings	25	15	10

For tension application, double insulator strings for 400kV/ 220 KV and single insulator strings for 132 kV system shall be used. For suspension purpose single suspension insulator string shall be used for 400 kV, 220 KV & 132 kV system as per standard.

1.4.2.1 **INSULATOR STRING (33 KV)**

a)	Power frequency withstand voltage of the complete string with Corona Control ring (wet) - kV rms	:	75
b)	Lightning impulse withstand Voltage of string with corona control rings (dry) – kVp	:	±170
c)	Power frequency puncture with-stand voltage for a string insulator	:	1.3 times wet flashover voltage of the unit
d)	Total creepage distance of the complete insulator string (mm)	:	900
f)	Total no. of discs per strings	:	5 (S/T & S/S)

1.5 **COMPOSITE LONG ROD INSULATOR**

As an alternative to disc insulator/long rod porcelain, Bidder can also offer composite long rod insulators with suitable hardware.

1.5.1 **Details of Composite Long Rod Insulators**

1.5.1.1 Contractor shall offer such composite insulators, which have proven use under foggy/ humid operational conditions in polluted industrial environment combined with smoke and dust particles. The Bidder shall furnish evidence in the form of certification from the power utilities that the similar type of product supplied to them had been performing satisfactory. The Bidder shall also submit certified test report for an accelerated ageing test of 5000 hours such as that described in Appendix-C of IEC-61109 or test at multiple stresses of 5000 hrs as described in annexure –B of IEC-62217.

1.5.1.2 Insulators shall have sheds of the "open aerodynamic profile without any under ribs" with good self-cleaning properties. Insulator shed profile, spacing projection etc. shall be strictly in accordance with the recommendation of IEC-60815.

1.5.2 Ball and socket shall be 20 mm designation for 120 kN & 24 mm designation for 210 kN Insulators in accordance with the standard dimensions stated in

IEC:60120. Insulators shall be interchangeable and shall be suitable for forming either suspension or tension strings. Each insulator shall have rated strength markings on each composite insulator rod unit. no negative tolerance shall be applicable to creepage distance of composite insulators

1.5.3 All ferrous parts shall be hot dip galvanized to give a minimum average coating of zinc equivalent to 610 gm/sq.m. and shall be in accordance with the latest edition of equivalent International standard. The zinc used for galvanizing shall be of purity of 99.95%. The zinc coating shall be uniform, adherent, smooth, reasonably bright continuous and free from imperfections such as flux, ash rust stains, bulky white deposits and blisters. The galvanized metal parts shall be guaranteed to withstand at least six successive dips each lasting for one (1) minute duration under the standard preece test. The galvanizing shall be carried out only after any machining.

1.5.4 **Materials**

1.5.4.1 **Core**

It shall be a glass-fiber reinforced (FRP rod) epoxy resin rod of high strength. The rod shall be resistant to hydrolysis. Glass fibers and resin shall be optimized. The rod shall be electrical grade corrosion resistant (ECR), boron free glass and shall exhibit both high electrical integrity and high resistance to acid corrosion.

1.5.4.2 **Housing & Weathersheds**

The FRP rod shall be covered by a sheath of a silicone rubber compound of a thickness of minimum 3mm. The housing & weathersheds should have silicon content of minimum 30% by weight. It should protect the FRP rod against environmental influences, external pollution and humidity. It shall be extruded or directly molded on the core. The interface between the housing and the core must be uniform and without voids. The strength of the bond shall be greater than the tearing strength of the polymer. The manufacturer shall follow non-destructive technique (N.D.T.) to check the quality of jointing of the housing interface with the core.

The weathersheds of the insulators shall be of alternate shed profile. The weathersheds shall be vulcanized to the sheath (extrusion process) or molded as part of the sheath (injection moulding process) and free from imperfections. The vulcanization for extrusion process shall be at high temperature and for injection moulding shall be at high temperature & high pressure. Any seams/ burrs protruding axially along the insulator, resulting from the injection moulding process shall be removed completely without causing any damage to the housing. The track resistance of housing and shed material shall be class 1A4.5 according to IEC60587. The strength of the weathershed to sheath interface shall be greater than the tearing strength of the polymer. The composite insulator shall be capable of high pressure washing.

1.5.4.3 **End Fittings**

End fittings transmit the mechanical load to the core. They shall be made of malleable cast iron/ spheroidal graphite or forged steel. They shall be connected to the rod by means of a controlled compression technique. The manufacturer shall have in-process Acoustic emission arrangement or some other arrangement to ensure that there is no damage to the core during crimping. This verification shall be in-process and done on each insulator. The system of attachment of end fitting to the rod shall provide superior sealing performance between housing and metal connection. The gap between fitting and sheath shall be sealed by a flexible silicone rubber compound. The sealing shall stick to both housing and metal end fitting. The sealing must be humidity proof and durable with time.

End fittings shall have suitable provisions for fixing grading rings at the correct position as per design requirements.

1.5.4.4 **Grading Rings**

Grading rings shall be used at both ends of each composite insulator unit for reducing the voltage gradient on and within the insulator and to reduce radio and TV noise to acceptable levels. The size and placement of the metallic grading rings shall be designed to eliminate dry band arcing/corona cutting/ exceeding of permissible electrical stress of material.

1.5.2 **Tests and Standards**

1.5.2.1 **Type Tests**

The test reports for following type tests on long rod units, components, materials or complete strings shall be submitted for approval as per clause 9.2 of Chapter 2 - GTR.

1.5.2.1.1 On the complete composite Long Rod Insulator String with Hardware Fittings:-

a) Power frequency voltage withstand test with corona control rings/grading ring and arcing horns (if provided) under wet condition as per IEC:60383-1993/

b) Switching surge voltage withstand test under wet condition as per IEC:60383-1993.

c) Impulse voltage withstand test under dry condition as per IEC:60383-1993

d) Corona and RIV test under dry condition.

The sample assembly when subjected to power frequency voltage shall have a corona extinction voltage of not less than 156kV (rms) for 220kV line to ground under dry condition. There shall be no evidence of Corona on any part of the sample. The atmospheric condition during testing shall be recorded and the test results shall be accordingly corrected with suitable correction for as stipulated in IEC 60383.

Under the conditions as specified above the insulator string alongwith complete hardware fittings shall have a radio interference voltage level below 1000 microvolts at 1 MHz when subjected to 50 Hz AC line to ground voltage of 156kV for 220kV under dry conditions. The test procedure shall be in accordance with IEC 60437.

e) Mechanical Strength test

The complete insulator string alongwith its hardware fitting excluding arcing horn, corona control ring, grading ring, tension/suspension clamps shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. The load shall be held for five minutes and then removed. After removal of the load, the string components shall not show any visual deformation and it shall be possible to dismantle them by hand. Hand tools may be used to remove cotter pins and loosen the nuts initially. The string shall then be reassembled and loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified minimum UTS and held for one minute. No failure should occur during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

f) Salt-fog pollution withstand test as per IEC: 60507. The salinity level for composite long rod insulators shall be 160 Kg/m3 NACL.

1.5.2.1.2 **On Composite Insulator Units**

a) Tests on interfaces and connections of metal fittings as per IEC: 61109-2008.

b) Assembled core load time test as per IEC: 61109-2008.

c) Damage limit proof test and test of tightness of interface between end firings and insulator housing as per IEC: 61109-2008

d) High Pressure washing test

The washing of a complete insulator of each E&M rating is to be carried out at 3800 kPa with nozzles of 6 mm diameter at a distance of 3m from nozzles to the insulator, The washing shall be carried out for 10minutes. There shall be no damage to the sheath or metal fitting to housing interface.

e) Brittle frure resistance test

The test arrangement shall be according to Damage limit proof test with simultaneous application of 1N-HNO3 acid directly in cont with naked FRP rod.

The cont length of acid shall not be less than 40mm and thickness around the core not less than 10mm.The rod shall withstand 80% of SML for 96 hours.

f) Dye penetration test as per IEC: 61109-2008

g) Water diffusion test as per IEC: 61109-2008

h) Tracking and erosion test as per IEC: 61109-2008.

i) Hardness test as per IEC: 61109-2008.

j) Accelerated weathering test as per IEC: 61109-2008.

k) Flammability test as per IEC: 61109-2008.

l) Silicone content test

Minimum content of silicone as guaranteed by supplier shall be verified through FT-IR spectroscopy & TGA analysis or any other suitable method mutually agreed between Employer & Supplier in Quality Assurance Programme.

m) Recovery of Hydrophobicity test

1. The surface of selected samples shall be cleaned with isopropyl alcohol. Allow the surface to dry and spray with water. Record the HC classification. Dry the sample surface.

2. Treat the surface with corona discharges to destroy the hydrophobicity. This can be done utilizing a high frequency corona tester, Holding the electrode approximately 3mm from the sample surface, slowly move the electrode over an area approximately 1" x 1". Continue treating this area for 2 – 3 minutes, operating the tester at maximum output.

3. Immediately after the corona treatment, spray the surface with water and record the HC classification. The surface should be hydrophilic, with an HC value of 6 or 7. If not, dry the surface and repeat the corona treatment for a longer time until an HC of 6 or 7 is obtained. Dry the sample surface.

4. Allow the sample to recover and repeat the hydrophobicity measurement at several time intervals. Silicone rubber should recover to HC 1 – HC 2 within 24 to 48 hours, depending on the material and the intensity of the corona treatment.

n) Torsion test

Three complete insulators of each E&M rating shall be subjected to a torsional load of 55Nm. The torsional strength test shall be made with test specimen adequately secured to the testing machine. The torsional load shall be applied to the test specimen through a torque member so constructed that the test specimen is not subjected to any cantilever stress. The insulator after torsion test must pass the Dye Penetration Test as per IEC 61109.

o) Accelerated ageing test of 5000hrs as described in appendix-C of IEC 61109 or Test at multiple stresses of 5000 hrs as described in Annex-B of IEC -62217

1.5.2.2 ***Acceptance Tests:***

1.5.2.2.1 ***For Composite Long Rod Insulators***

a.	Verification of dimensions	IEC : 61109-2008
b.	Galvanizing test	IEC : 60383
c.	Verification of end fittings	IEC : 61109-2008
d.	Recovery of Hydrophobicity	As per above
e.	Verification of tightness of interface between end fittings and insulator housing and of specified mechanical load	IEC : 61109-2008
f.	Silicone content test	As per above
g.	Brittle frure resistance test	As per above
h.	Dye penetration test	IEC : 61109-2008
i.	Water diffusion test	IEC : 61109-2008

In the event of failure of the sample to satisfy the acceptance test(s) specified in 4.2 above, the retest procedure shall be as per IEC 61109.

1.5.2.3 **Routine Tests**

1.5.2.3.1 **For Composite Long Rod Insulator Units**

a)	Visual Examination	As per IEC:61109-2008
b)	Mechanical routine test	As per IEC:61109 -2008

2.0 **AAC / ACSR CONDUCTOR**

2.1 **Details of AAC Conductor**

2.1.1 The contractor shall supply the conductor as per the standard guaranteed technical particulars enclosed in Annexure-A of the technical specification, Chapter 11 – Switchyard Erection and separate approval is not required during detailed engineering.

Owner has also standardised the guaranteed technical particulars for the conductors which are enclosed in Annexure-A of the technical specification, Chapter 11 – Switchyard Erection. The contractor shall supply the conductor as per the standard guaranteed technical particulars.

2.1.2 The details of the AAC Bull conductor are tabulated below:

Sl. No.	**Description**	**Unit**	**AAC BULL**
a)	Stranding and wire diameter	mm	61/4.25
b)	Number of Strands		
	1st Aluminium Layer	Nos.	1
	2nd Aluminium Layer	Nos.	6
	3rd Aluminium Layer	Nos.	12
	4th Aluminium Layer	Nos.	18
	5th Aluminium Layer	Nos.	24
c)	Total sectional area	Sq.mm	865.36
d)	Overall diameter	mm	38.25
e)	Approximate weight	kg/ km	2400
f)	Calculated d.c. resistance at 20oC	ohm/km	0.0334
g)	Minimum UTS	kN	139

2.1.3 The details of Aluminium strand are as follows:

Sl. No.	**Description**	**Unit**	**AAC BULL**
a)	Minimum breaking load of strand before stranding	KN	2.23
b)	Minimum breaking load of strand after stranding	KN	2.12
c)	Maximum D.C. resistance of strand at 20 deg. Centigrade	Ohm/KM	3.651

2.2 **Details of ACSR Conductor**

2.2.1 The details of the ACSR Moose conductors shall be as per the standard guaranteed technical particulars enclosed in Annexure-A are tabulated below:

ACSR MOOSE CONDUCTOR:

Sl. No.	Description	Unit	ACSR MOOSE
a)	Stranding and wire diameter	mm	54/3.53 (Al)+ 7/3.53 (Steel)
b)	Number of Strands		
	Steel centre	Nos.	1
	1st Steel Layer	Nos.	6
	1st Aluminium Layer	Nos.	12
	2nd Aluminium Layer	Nos.	18
	3rd Aluminium Layer	Nos.	24
c)	Sectional area of Aluminium	Sq. mm	528.5
d)	Total sectional area	Sq. mm	597.00
e)	Overall diameter	mm	31.77
f)	Approximate weight	kg/ km	2004
g)	Calculated d.c. resistance at 20oC	ohm /km	0.05552
h)	Minimum UTS	kN	161.2

2.2.2 The details of Aluminium strand are as follows:

ACSR MOOSE CONDUCTOR:

Sl. No.	Description	Unit	ACSR MOOSE
a)	Minimum breaking load of strand before stranding	KN	1.57
b)	Minimum breaking load of strand after stranding	KN	1.49
c)	Maximum D.C. resistance of strand at 20 deg. Centigrade	Ohm /KM	2.921

2.2.3 The details of steel strand are as follows:

ACSR MOOSE CONDUCTOR:

Sl. No.	**Description**	**Unit**	**ACSR MOOSE**
a)	Minimum breaking load of strand before stranding	KN	12.86
b)	Minimum breaking load of	KN	12.22

	strand after stranding		
c)	Minimum number of twists to be withstood in torsion test when tested on a gauge length of 100 times diameter of wire	Nos.	18 (Before stranding) 16 (Before stranding

2.3 Workmanship

2.3.1 The finished conductor shall be smooth, comp, uniform and free from all imperfections including kinks (protusion of wires), wire cross over, over riding, looseness (wire being dislocated by finger/hand pressure and/or unusual bangle noise on tapping), material inclusions, white rust, powder formation or black spot (on account of reion with trapped rain water etc.), dirt, grit etc.

2.3.2 All the Aluminium and steel strands shall be smooth, uniform and free from all imperfections, such as spills and splits, diemarks, scratches, abrasions, etc., after drawing.

2.3.3 The steel strands shall be hot dip galvanised and shall have a minimum zinc coating of 260 gms/sq.m. after stranding of the uncoated wire surface. The zinc coating shall be smooth, continuous and of uniform thickness, free from imperfections and shall withstand minimum three dips in standard Preece test. The finished strands and the individual wires shall be of uniform quality and have the same properties and chareristics as prescribed in ASTM designation : B 498-74.

2.3.4 The steel strands shall be preformed and post formed in order to prevent spreading of strands in the event of cutting of composite core wire. Care shall be taken to avoid, damages to galvanisation during pre-forming and post-forming operation.

2.4 Joints in Wires

2.4.1 Aluminium Wires

Joints in aluminium wires shall be as per relevant International standard.

2.4.2 Steel Wires

There shall be no joint of any kind in the finished wire entering into the manufacture of the strand. There shall also be no strand joints or strand splices in any length of the completed stranded steel core of the conductor.

2.5 Tolerances

The manufacturing tolerances shall be as per relevant International standard.

A. AAC Bull and AAC Tarantala conductor:

a)	Diameter of Aluminium and Steel Strands						
		AAC BULL			AAC TARANTALA		
		Standard	Maximum	Minimum	Standard	Maximum	Minimum
	Aluminium	4.25 mm	4.29 mm	4.21 mm	5.23	5.28	5.18

b)	Lay ratio of Conductor					
			AAC BULL		AAC TARANTALA	
			Maximum	Minimum	Maximum	Minimum
	Aluminium	6 wire layer	16	10	16	10
		12 wire layer	16	10	16	10
		18 wire layer	16	10	16	10
		24 wire layer	14	10	-	-

B. ACSR Bersimis and ACSR Moose conductor:

a)	Diameter of Aluminium and Steel Strands						
		ACSR BERSIMIS			ACSR MOOSE		
		Standard	Maximum	Minimum	Standard	Maximum	Minimum
	Aluminium	4.57 mm	4.61 mm	4.53 mm	3.53 mm	3.55 mm	3.51 mm
	Steel	2.54 mm	2.57 mm	2.51 mm	3.53 mm	3.60 mm	3.46 mm

b)	Lay ratio of Conductor					
			ACSR BERSIMIS		ACSR MOOSE	
			Maximum	Minimum		
	Steel	6 wire layer	18	13	18	16
	Aluminium	8/12 wire layer	17	10	14	12
		14/18 wire layer	16	10	13	11
		20/24 wire layer	14	10	12	10

2.6 Materials

2.6.1 Aluminium

The aluminium strands shall be hard drawn from electrolytic aluminium rods having purity not less than 99.5% and a copper content not exceeding 0.04%.

2.6.2 Steel

The steel wire strands shall be drawn from high carbon steel wire rods and shall conform to the following chemical composition:

Element	% Composition
Carbon	0.50 to 0.85
Manganese	0.50 to 1.10
Phosphorous	Not more than 0.035
Sulphur	Not more than 0.045
Silicon	0.10 to 0.35

2.6.3 **Zinc**

The zinc used for galvanising shall be electrolytic High Grade Zinc of 99.95% purity.

2.7 **Standard Length**

2.7.1 The conductor shall be supplied as required. No joint shall be allowed within a single span of stringing, jumpers and equipment interconnection.

2.8 Tests :

2.8.1 The following type, acceptance & routine tests and tests during manufacturing shall be carried out on the conductor.

2.8.2 **Type Tests**

In accordance with the stipulation of specification, the following type tests reports of the conductor shall be submitted for approval as per clause 9.2 of Chapter 2 -GTR.

a) UTS test on stranded conductor. .

b) Corona extinction voltage test (dry)

(c) Radio Interference voltage test (dry)

(d) DC resistance test on stranded conductor

2.8.3 **Acceptance Tests**

a) Visual check for joints, scratches etc. and lengths of conductor

b) Dimensional check on steel and aluminium strands

c) Check for lay ratios of various layers

d) Galvanising test on steel strands

e) Torsion and Elongation

test on steel strands

f) Breaking load test on steel and aluminium strands

g) Wrap test on steel and aluminium strands

h) DC resistance test on aluminium strands

i) UTS test on welded joint of aluminium strands

NOTE:

All the above tests except test mentioned at (a) shall be carried out on aluminium and steel strands after stranding only.

2.8.4 **Routine Tests**

a) Check to ensure that the joints are as per specification.

b) Check that there are no cuts, fins etc. on the strands.

c) All acceptance test as mentioned in Clause 2.7.3 above to be carried out on each coil.

2.8.5 **Tests During Manufacturer**

a) Chemical analysis of zinc used for galvanising

b) Chemical analysis of aluminium used for making aluminium strands

c) Chemical analysis of steel used for making steel strands

2.8.6 **Sample Batch for Type Testing**

The Contractor shall offer material for selection of samples for type testing, only after getting quality assurance plans approved from Owner's Quality Assurance Department. The sample shall be manufactured strictly in accordance with the

Quality Assurance Plan approved by Owner.

3.0 Galvanised Steel Earth wire

3.1 Details of Earth wire

3.1.1 The contractor shall supply the earthwire as per the standard guaranteed technical particulars enclosed in Annexure-A of the technical specification, Chapter 11 – Switchyard Erection and separate approval is not required during detailed engineering.

Owner has also standardised the guaranteed technical particulars for the earthwire which are enclosed in Annexure-A of the technical specification, Chapter 11 – Switchyard Erection. The contractor shall supply the earthwire as per the standard guaranteed technical particulars.

3.1.2 The basic details of the earth wire are tabulated below:

Sl.No.	Description	Unit	Value
1.	Stranding & Wire diameter	mm	7/3.66 (steel)
2.	Strands a) Steel Core b) Outer layer	 No. No.	 1 (one) 6 (six)
3.	Total sectional area	Sq. mm.	73.65

Other technical details are furnished in of Annexure -A of this Specification.

3.2 Workmanship

3.2.1 All steel strands shall be smooth, uniform and free from all imperfections, such as spills and splits, die marks, scratches, abrasions and kinks after drawing and also after stranding.

3.2.2 The finished material shall have minimum brittleness as it will be subjected to appreciable vibration while in use.

3.2.3 The steel strands shall be hot dip qalvanised (and shall have minimum Zinc coating of 275 gms/sq.m) after stranding of the uncoated wire surface. The zinc coating shall be smooth, continuous, of uniform thickness, free from imperfections and shall withstand three and a half dips after stranding in standard Preece test. The steel wire rod shall be of such quality and purity that, when drawn to the size of the strands specified and coated with zinc, the finished strands shall be of uniform quality and have the same properties and chareristics as prescribed in ASTM designation B498-74.

3.2.4 The steel strands shall be preformed and post formed in order to prevent spreading of strands while cutting of composite earth wire. Care shall be taken to avoid damage to galvanisation during preforming and postforming operation.

3.2.5 To avoid susceptibility towards wet storage stains (white rust), the finished material shall be provided with a protective coating of boiled linseed oil.

3.3 Joints in Wires

There shall be no joint of any kind in the finished steel wire strand entering into the manufacture of the earth wire. There shall be no strand joints or strand splices in any length of the completed stranded earth wire.

3.4 Tolerances

The manufuring tolerance to the extent of the following limits only shall be permitted in the diameter of the individual steel strands and lay length of the earth wire:

	Standard	Maximum	Minimum
Diameter	3.66 mm	3.75 mm	3.57 mm
Lay length	181 mm	198 mm	165 mm

3.5 **Materials**

3.5.1 Steel

The steel wire strands shall be drawn from high carbon steel rods and shall conform to the following requirements as to the chemical composition.

Element	% Composition
Carbon	Not more than 0.55
Manganese	0.4 to 0.9
Phosphorous	Not more than 0.04
Sulphur	Not more than 0.04
Silicon	0.15 to 0.35

3.5.2 Zinc

The zinc used for galvanising shall be electrolytic High Grade Zinc of 99.95% purity. It shall conform to and satisfy all the requirements of relevant international standard.

3.6 Standard Length

3.6.1 The earth wire shall be supplied in standard drum length of manufacturer.

3.8 **TESTS**

3.8.1 The following type, routine & acceptance tests and tests during manufacturing shall be carried out on the earthwire.

3.8.2 **TYPE TESTS**

In accordance with the stipulation of specification, the following type tests reports of the earthwire shall be submitted for approval as per clause 9.2 of Chapter 2 - GTR.

a) UTS test

b) DC resistance test

3.8.3 **ACCEPTANCE TESTS**

a) Visual check for joints, scratches etc. and length of Earthwire

b) Dimensional check

c) Galvanising test

d) Lay length check

e) Torsion test

f) Elongation test

g) Wrap test

h) DC resistance test

i) Breaking load test

j) Chemical Analysis of steel

3.8.4 **ROUTINE TESTS**

a) Check that there are no cuts, fins etc. on the strands.

b) Check for correctness of stranding.

3.8.5 **TESTS DURING MANUFACTURE**

a) Chemical analysis of zinc used for galvanising

b) Chemical analysis of steel

3.8.6 **SAMPLE BATCH FOR TYPE TESTING**

The Contractor shall offer material for sample selection for type testing, only after getting quality assurance programme approved by the Owner. The samples for type testing shall be manufactured strictly in accordance with the Quality Assurance Programme approved by the Owner.

4.0 **TUBULAR BUS CONDUCTORS**

4.1 **General**

The contractor shall supply the aluminium tubes as per the standard guaranteed technical particulars enclosed in Annexure- A of the technical specification, Chapter 14 – Switchyard Erection and separate approval is not required during detailed engineering.

Owner has also stardardised the guaranteed technical particulars for the aluminium tube which are enclosed in Annexure- A of the technical specification, Chapter 14 – Switchyard Erection. The contractor shall supply the aluminium tube as per the standard guaranteed technical particulars.

4.2 **Constructional Features**

4.2.1 For outside diameter (OD) & thickness of the tube there shall be no minus tolerance, other requirements being as per relevant International standard.

4.2.2 The aluminium tube shall be supplied in suitable cut length to minimize wastage.

4.2.3 The welding of aluminium tube shall be done by the qualified welders duly approved by the owner.

4.3 **Tests**

In accordance with stipulations of the specification, Routine tests shall be conducted on tubular bus conductors. Also the wall thickness and ovality of the tube shall be measured. In addition to the above tests, 0.2% proof tests on both parent metal and Aluminium tube after welding shall be conducted.

4.4 **Technical Parameters**

Sl. No.	Description	3" AL. TUBE	4" AL. TUBE	4.5" AL. TUBE	5" AL. TUBE
1.	Type	3" IPS	4" IPS	4.5" IPS	5" IPS
		(EH Type)	(EH Type)	(EH Type)	(H Type)
2.	Outer diameter	88.9 mm	114.2 mm	120.00 mm	141.30 mm

3.	Thickness	7.62 mm	8.51 mm	12.00 mm	9.53 mm
4.	Cross-sectional area of aluminium	1945.76 sq.mm	2825.61 sq.mm	4071.50 sq.mm	3945.11 sq.mm
5.	Weight	5.25 kg/m	7.7 kg/m	11.034 kg/m	10.652 kg/m

Sl. No.	Description	6" AL. TUBE	8" AL. TUBE	10" AL. TUBE
1.	Type	6‖ IPS (H Type)	8‖ IPS (H Type)	10‖ IPS (H Type)
2.	Outer diameter	150 mm	202 mm	252 mm
3.	Thickness	10 mm	16 mm	17 mm
4.	Cross-sectional area of aluminium	4398.2 Sq mm	9349.3 sq.mm	12550.6 sq.mm
5.	Weight	11.875 kg/m	25.243 kg/m	33.887 kg/m

5..1 Constructional Features of Galvanized Steel

a) The minimum weight of the zinc coating shall be 618 gm/sq. m. and minimum thickness shall be 85 microns.

b) The galvanised surfaces shall consist of a continuous and uniformly thick coating of zinc, firmly adhering to the surfaces of steel. The finished surface shall be clean and smooth and shall be free from defects like discoloured patches, bare spots, unevenness of coating, spelter which is loosely attached to the steel globules, spiky deposits, blistered surfaces, flaking or peeling off etc. The presence of any of these defects noticed on visual or microscopic inspection shall render the material liable to rejection.

5.2 Tests

In accordance with stipulations of the specifications galvanised steel shall be subjected to four one minute dips in copper sulphate solution as per relevant international standard.

6.0 **SPACERS**

6.1 **General**

The spacers are to be located at a suitable spacing to limit the short circuit forces as per IEC -60865. Wherever Employer's 400 kV, 220kV & 132kV standard gantry structures are being used, the spacer span(s) for different conductor / span configurations and corresponding short circuit forces shall be as per relevant IEC. For strung buses, flexible type spacers shall be used whereas for jumpers and other connections rigid type spacers shall be used.

Wherever Employer's 400kV, 220kV & 132kV standard gantry structures are not being used, necessary spacer span calculation shall be provided by the contractor during detailed engineering for the approval of Employer.

6.2 **Constructional Features**

6.2.1 No magnetic material shall be used in the fabrication of spacers except for GI bolts and nuts.

6.2.2 Spacer design shall be made to take care of fixing and removing during installation and maintenance.

6.2.3 The design of the spacers shall be such that the conductor does not come in cont with any sharp edge.

6.3 **Tests**

Each type of spacers shall be subjected to the following type tests, acceptance tests and routine tests:

6.3.1 Type Tests: Following type test reports shall be submitted for approval as per clause 9.2 of Chapter 2 - GTR.

a) **Clamp slip tests**

The sample shall be installed on test span of twin conductor bundle string or quadruple conductor bundle string (as applicable) at a tension of 44.2 kN. One of the clamps of the sample when subjected to a longitudinal pull of 2.5 kN parallel to the axis of the conductor shall not slip on the conductor. The permanent displacement between the conductor and the clamp of sample measured after removal of the load shall not exceed 1.0 mm. Similar tests shall be performed on the other clamps of the same sample.

b) Fault current test.

c) Corona Extinction Voltage Test (Dry).

This test shall be performed on 400kV and 220 kV equipment as per procedure mentioned at Chapter 2-GTR, Minimum Corona Extinction voltage shall be as per IEC.

d) RIV Test (Dry)

This test shall be performed as per procedure mentioned at Chapter 2-GTR, Maximum RIV level at 305 kV (rms) line to ground and 156 kV (rms) line to ground for 400kV and 220 kV spacers respectively shall be 1000 micro volts, across 300 ohm resistor at 1 MHz

e) Resilience test (if applicable)

f) Tension Test

g) Log decremant test (if applicable)

h) Compression test

i) Galvanising test

6.3.2 **Acceptance Test**

a) Visual examination
b) Dimensional verification
c) Movement test
d) Clamp slip test
e) Clamp bolt torque test (if applicable)
f) Assembly torque test
g) Compression test
h) Tension test
i) Galvanising test
j) Hardness test for neoprene (if applicable)
The shore hardness of different points on the elastometer surface of cushion grip clamp shall be measured by shore hardness meter. It shall be between 65 to 80.
k) Ultimate Tensile Strength Test
The UTS of the retaining rods shall be measured. It shall not be less than 35 kg/Sq. mm.

6.3.3 **Routine test**

a) Visual examination

b) Dimensional verification

7.0 **BUS POST INSULATORS**

The post insulators shall conform in general to latest IEC-60168, IEC 60273 and IEC-60815.

7.1 **Constructional Features**

7.1.1 Post type insulators shall consist of a porcelain part permanently secured in a metal base to be mounted on the supporting structures. They shall be capable of being mounted upright. They shall be designed to withstand any shocks to which they may be subjected to by the operation of the associated equipment. Only solid core insulators will be acceptable.

7.1.2 Porcelain used shall be homogeneous, free from lamination, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.

7.1.3 Glazing of the porcelain shall be of uniform brown in colour, free from blisters, burrs and other similar defects.

7.1.4 The insulator shall have alternate long and short sheds with aerodynamic profile, The shed profile shall also meet the requirements of IEC-60815 for the specified pollution level.

7.1.5 When operating at normal rated voltage there shall be no electric discharge between conductor and insulators which would cause corrosion or injury to conductors or insulators by the formation of substance produced by chemical ion.

7.1.6 The design of the insulators shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration.

7.1.7 All ferrous parts shall be hot dip galvanised. The zinc used for galvanising shall be grade Zn 99.95. The zinc coating shall be uniform, adherent, smooth, reasonably bright, continuous and free from imperfections such as flux ash, rust stains, bulky white deposits and blisters. The metal parts shall not produce any noise generating corona under the operating conditions.

7.1.8 a) Every bolt shall be provided with a steel washer under the nut so that part of the threaded portion of the bolts is within the thickness of the parts bolted together.

b) Flat washer shall be circular of a diameter 2.5 times that of bolt and of suitable thickness. Where bolt heads/nuts bear upon the beveled surfaces they shall be provided with square tapered washers of suitable thickness to afford a seating square with the axis of the bolt.

c) All bolts and nuts shall be of steel with well formed hexagonal heads forged from the solid and shall be hot dip galvanised. The nuts shall be good fit on the bolts and two clear threads shall show through the nut when it has been finally tightened up.

7.1.9 Bidder shall make available data on all the essential features of design including the method of assembly of shells and metals parts, number of shells per insulator, the manner in which mechanical stresses are transmitted through shells to adjacent parts, provision for meeting expansion stresses, results of corona and thermal shock tests, recommended working strength and any special design or arrangement employed to increase life under service conditions.

7.2 **Tests**

In accordance with the stipulations of the specification, the post insulators shall be subject to type, acceptance, sample and routine tests as per IEC-60168.

7.2.1 In addition to acceptance/sample/routine tests as per IEC-60168, the following tests shall also be carried out.

a) Ultrasonic test as an acceptance test

b) Soundness test, metallurgical tests and magnetic test on MCI caps and pedestal tests as acceptance test.

c) All hot dip galvanised components shall be subject to check for uniformity of thickness and weight of zinc coating on sample basis.

d) The bending test shall be carried out at 50% minimum failing load in four directions as a routine test and at 100% minimum failing load in four directions as an acceptance test.

e) Acceptance norms for visual defects allowed at site and also at works shall be agreed in the Quality plan.

7.2.2 In accordance with the stipulation of specification, the following type tests reports of the post insulators shall be submitted for approval as per clause 9.2 of Chapter 2 - GTR.

a) Power frequency withstand test (dry & wet)

b) Lightning impulse test (dry)

c) Measurement of R.I.V (Dry)

d) Corona extinction voltage test (Dry)

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e) Test for deflection under load

f) Test for mechanical strength.

7.3 **Technical Parameters of Bus Post Insulators.**

Sl. No.	Description	245 kV	400 kV
a)	Type	Solid Core	Solid Core
b)	Voltage Class (kV)	245	420

c)	Dry and wet one minute power frequency withstand voltage(kV rms)	460	680
d)	Dry lightning impulse withstand Voltage (kVp)	+ 1050	+1425
e)	Wet switching surge withstand voltage (kVp)	—-	+ 1050
f)	Max. radio interference voltage (in microvolts) at voltage of 305 kV (rms) and 156 (rms) for 400 kV &220 kV respectively between phase to ground.	500	500
g)	Corona extinction voltage (kV rms) (min.)	156	320
h)	***Cantilever Strength***		
(i)	Total minimum cantilever strength (Kg)	800	800
(ii)	***Total minimum breaking strength (Kg)***	***1000***	***1000***
i)	Minimum torsional moment	As per IEC-273	As per IEC-273
j)	Total height of insulator (mm)	2300	3650
k)	P.C.D Top (mm)	127	***127***
	Bottom (mm)	254	***300***
l)	No. of bolts		
	Top	4	***4***
	Bottom	8	***8***
m)	Diameter of bolt/holes (mm)		
	Top	M16	***M16***
	Bottom dia	18	***18***
n)	Pollution level as per IEC-815	Heavy(III)	Heavy(III)
o)	Minimum total creepage distance for Heavy Pollution (mm)	6125	10500

7.3.1 33kV Bus Post Insulators.

a) Type — Solid Core

b) Voltage class (kV) — 36

c) Dry and wet one minute power frequency withstand voltage(kV rms) — 70

d) Dry lightning impulse withstand Voltage (kVp) — ±170

e) Total minimum cantilever strength (Kg) — 450

f) Minimum torsional moment — As per IEC-273

g)	Total height of insulator (mm)	As per requirement
h)	Pollution level as per IEC-815	Heavy(III)
i)	Minimum creepage distance for Heavy Pollution (mm)	900

7.3.2 If corona extinction voltage is to be achieved with the help of corona ring or any other similar device, the same shall be deemed to be included in the scope of the Contractor. Material of Corona ring shall be aluminium/aluminium alloy of 63401W grade or equivalent.

8.0 GROUNDING SYSTEM

8.1 GENERAL

This specification covers the design, supply, delivery, installation and testing of the complete grounding system as described below.
The complete station grounding work shall be in accordance with the recommendation in the "Guide for Safety in Substation Grounding" IEEE No. 80 and the requirements of this section.

8.2 GROUNDING INSTALLATION FEATURES

8.2.1 The installation shall be complete in all respects for efficient and trouble free service. All work shall be carried out in a first class neat workman like manner. Grounding conductors shall be handled carefully to avoid kinking and cutting of the conductors during laying and installation.All exposed ground conductors runs shall be taken in a neat manner, horizontal, vertical and parallel to building walls or columns and shall not be laid haphazardly.

8.2.2 For all connections made to equipment or to the structures, the grounding conductor, connectors and equipment enclosures shall have good clean cont surfaces. Grounding conductor connection to all electrical equipment, switchgear, transformers, motors, panels, conduit system, equipment enclosures, cable trays, distribution boards, equipment frames, bases, steel structure, etc. shall be by pressure type or bolting type connectors.

8.2.3 All lap, cross and tee connections between two grounding conductors shall be made by thermowelding process or compression type connector. The various joints shall have adequate mechanical strength as well as necessary electrical conductivity not less than that of the parent conductors of the joints. All accessories for grounding installation shall be of quality and design approved by the Employer. The earthing connection between earthing pad of equipment/structures shall be made by two earthing leads.

8.2.4 Ground conductors, when crossing underground trenches, directly laid underground pipe and equipment foundation, if any, shall be at least 300mm below the bottom elevation of such trenches/pipes.

8.2.5 The maximum size of each grid of grounding mat shall not exceed 4X4 meters. The terminals for connecting ground mat and equipment shall be terminated whenever necessary. (The new grounding shall be bonded with existing grounding network.) at Inaruwa and Hetauda Substations.

8.3 GROUNDING CONDUCTOR

8.3.1 Main Ground Grid
The main ground system shall consist of a grounding grid buried minimum 0.6 meter below grade level. The grounding grid shall consist of copper flat conductor cable or stranded copper wire of minimum size (cross sectional area) 160sq. mm.

8.3.2 Ground Electrodes
The ground electrodes shall be 16mm diameter and 3.0 meter long (min.) copper clad steel. Theseshall be driven into ground and connected to the main ground grid.

8.3.3 Risers
The risers shall consist of copper conductor of adequate size (but not less than 160 sq. mm.) connected at one end to the main ground mat and at the other end to the equipment.

8.4 DESIGN REQUIREMENTS

8.4.1 The Contractor shall measure the soil resistivity in presence of the Employer. Based on the resistivity the contractor shall calculate the total length of buried ground conductor, number of grounding electrode and their depth and spacing to achieve a grounding system resistance of less than 1.0 (One) Ohm.

8.4.2 The Contractor shall calculate the cross-section considering the maximum fault level of 50 kA.

8.4.3 The Contractor shall submit the details of calculations of the grounding system for the Employer's approval. The earthing system shall be of single earthing system for the whole substation i.e. all earthings shall be connected to main earthing grid.

8.5 TESTS

On completion of the installation, either wholly or in sections, it shall be tested in compliance with relevant Code by the Contractor in presence of the Employer. The cost of any test including labor, material and equipment charges shall be borne by the Contractor. If the ground grid resistance can not be obtained as per his design, then additional grounding conductors shall be buried in the earth, or if necessary, buried in treated soil to obtain the required low ground resistance without any additional cost.

8.6 LIGHTNING PROTECTION

The outdoor equipment of the substation and the substation building shall be protected against lightning. The lightning protection shall be achieved by an overhead lightning shield system of galvanized steel wire of 7/3.35 mm, which shall be connected to the main grounding grid by steel conductor of 7/3.35 mm. Lighting mast with electrode length of 2.5mtr (maximum) may be used in sqitchyard area for lighting protection as per requirement. The above electrode may be connected to the main grounding grid by steel conductor of 7/3.35 mm . The design of the lightning protection system shall be subject to the approval of the Employer.

8.7 DRAWINGS

After award of the Contract, the Contractor shall furnish the grounding layout drawing with dimensions showing the location of grounding grids, electrodes, test link chambers and risers, backed up by necessary calculations for Employer's approval. The work shall have to be started at site only after getting approval from the Employer. If alteration is required for any work done before getting Employer's approval, the same shall have to be done by the Contractor at no extra cost to the Employer.

STATION GROUNDING SYSTEM

DESCRIPTION	UNIT	REQD
1. Main ground grid conductor material		Copper
2. Main ground grid conductor size	Sq.mm	≥ 160
3. Cross section of riser conductors	Sq mm	≥ 160
4. Ground electrodes		
-Material		Copper clad steel
-Diameter	mm	≥16
-Length	meter	3
5. Material of risers		Copper
6. Earthing system designed for	ohm	≤ 1

9.0 Main Bus Bars (Applicable for Aluminium tube)

The brief description of the bus switching scheme, bus bar layout and equipment connection to be adopted are indicated elsewhere in the specification. The bus bar arrangements are shown in drgs enclosed with the bid documents.

9.1 The Contractor shall furnish supporting calculations where applicable for the bus bars/conductors to show adequacy of design parameters for:

a) Fibre-stress

b) Cantilever strength of post insulators

c) Aeolain vibrations

d) Vertical deflection of bus bars

e) Short circuit forces in bundle conductor and spacer location for each span of ACSR conductor stringing as per layout drawings.

9.1.1 The welds in the aluminium tubes shall be kept to the minimum and there shall not be more than one weld per span. The procedure and details of welding shall be subject to Owner's approval. Material for welding sleeve shall be same as that of Aluminium tube. Welding sleeve shall be of 600mm length

9.1.2 Corona bells shall be provided wherever the bus extends beyond the clamps and on free ends, for sealing the ends of the tubular conductor against rain and moisture and to reduce the electrostatic discharge loss at the end points. There shall be a small drain hole in the corona bell. The material of Corona bell shall be Aluminium alloy similar to that of clamps & connectors.

9.1.3 To minimise the vibrations in the aluminium tubes, damping conductor shall be provided inside the aluminium tubes. For this purpose, the cut pieces of ACSR conductor which otherwise are considered wastages, shall be used as damping conductor.

9.1.4 Details of past experience of the persons proposed to be employed for Aluminium tube welding and the test reports of the welded pieces to prove the electrical and mechanical chareristics shall also be furnished along with the bid. Welding at site shall be done by adopting a qualified procedure and employing qualified welders as per ASME-Section IX.

10.0 **BAY EQUIPMENT**

10.1 The disposition of various bay equipments shall be as per single line diagrams and layout drawings.

10.2 Bay Marshalling Kiosk:-

One no. of bay marshalling kiosk shall be provided for each 220 kV and 400 kV bay under present scope. In addition to the requirements specified elsewhere in the specification, the bay marshalling kiosk shall have two distinct compartments for the following purpose:-

(i) To receive two incoming 400V, 3 phase, 63Amps, AC supply with auto changeover and MCB unit and distribute minimum six outgoing 400V, 3 phase, 16 Amps AC supplies controlled by MCB.

(ii) To distribute minimum ten outgoing 230V, 10 Amps single phase supplies to be controlled by MCB to be drawn from above 3 phase incomers.

(iii) 200 nos. terminal blocks in vertical formation for interlocking facilities for substations without automation system.

(iv) Necessary Terminal Blocks for terminating cables from ACDB and switchyard panel rooms.

11.0 EQUIPMENT ERECTION DETAILS

11.1 For equipment interconnection, the surfaces of equipment terminal pads, Aluminium tube, conductor & terminal clamps and connectors shall be properly cleaned. After cleaning, cont grease shall be applied on the cont surfaces of equipment terminal pad, Aluminium tube/conductor and terminal clamps to avoid any air gap in between. Subsequently bolts of the terminal pad/terminal connectors shall be tightened and the surfaces shall be cleaned properly after equipment interconnection.

11.2 Muslin or leather cloth shall be used for cleaning the inside and outside of hollow insulators.

11.3 All support insulators, circuit breaker interrupters and other fragile equipment shall preferably be handled with cranes having suitable booms and handling capacity.

11.4 Bending of Aluminium tube and compressed air piping if any should be done by a bending machine and through cold bending only. Bending shall be such that inner diameter of pipe is not reduced.

11.5 Cutting of the pipes wherever required shall be such as to avoid flaring of the ends. Hence only a proper pipe cutting tool shall be used. Hack saw shall not be used.

11.6 Handling of equipment shall be done strictly as per manufacturer's/supplier's instructions/instruction manual.

11.7 Handling equipment, sling ropes etc. should be tested periodically before erection for strength.

11.8 The slings shall be of sufficient length to avoid any damage to insulator due to excessive swing, scratching by sling ropes etc.

12.0 **STORAGE**

12.1 The Contractor shall provide and construct adequate storage shed for proper storage of equipments, where sensitive equipments shall be stored indoors. All equipments during storage shall be protected against damage due to s of nature or accidents. The storage instructions of the equipment manufacturer/Owner shall be strictly adhered to.

13.0 **CABLING MATERIAL**

13.1 **CABLE TAGS AND MARKERS**

13.1.1 Each cable and conduit run shall be tagged with numbers that appear in the cable and conduit schedule.

13.1.2 The tag shall be of aluminium with the number punched on it and securely attached to the cable conduit by not less than two turns of 20 SWG GI wire. Cable tags shall be of rectangular shape for power cables and of circular shape for control cables.

13.1.3 Location of cables laid directly underground shall be clearly indicated with cable marker made of galvanised iron plate.

13.1.4 Location of underground cable joints shall be indicated with cable marker with an additional inscription "Cable joints".

13.1.5 The marker shall project 150 mm above ground and shall be spaced at an interval of 30 meters and at every change in direction. They shall be located on both sides of road and drain crossings.

13.1.6 Cable tags shall be provided on all cables at each end (just before entering the equipment enclosure), on both sides of a wall or floor crossing, on each duct/conduit entry and at each end & turning point in cable tray/trench runs. Cable tags shall be provided inside the switchgear, motor control centres, control and relay panels etc., wherever required for cable identification, where a number of cables enter together through a gland plate.

13.2 **Cable Supports and Cable Tray Mounting Arrangements**

13.2.1 The Contractor shall provide embedded steel inserts on concrete floors/walls to secure supports by welding to these inserts or available building steel structures.

13.2.2 The supports shall be fabricated from standard structural steel members.

13.2.3 Insert plates will be provided at an interval of 750 mm wherever cables are to be supported without the use of cable trays, such as in trenches, while at all other places these will be at an interval of 2000 mm.

13.2.4 Vertical run of cables on equipment support structure shall be supported on perforated cable trays of suitable width which shall be suitably bolted/clamped with the equipment support structure.

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13.3 **Cable Termination and Connections**

13.3.1 The termination and connection of cables shall be done strictly in accordance with cable and termination kit manufacturer's instructions, drawing and/or as directed by the Owner.

13.3.2 The work shall include all clamping, fittings, fixing, plumbing, soldering, drilling, cutting, taping, heat shrinking (where applicable), connecting to cable terminal, shorting and grounding as required to complete the job.

13.3.3 Supply of all consumable material shall be in the scope of Contractor.

13.3.4 The equipment will be generally provided with undrilled gland plates for cables/conduit entry. The Contractor shall be responsible for drilling of gland plates, painting and touching up. Holes shall not be made by gas cutting.

13.3.5 Control cable cores entering control panel/switchgear/MCCB/MCC/ miscellaneous panels shall be neatly bunched, clamped and tied with nylon strap or PVC perforated strap to keep them in position.

13.3.6 The Contractor shall tag/ferrule control cable cores at all terminations, as instructed by the Owner. In panels where a large number of cables are to be terminated and cable identification may be difficult, each core ferrule may include the complete cable number as well.

13.3.7 Spare cores shall be similarly tagged with cable numbers and coiled up.

13.3.8 All cable entry points shall be sealed and made vermin and dust proof. Unused openings shall be effectively closed.

13.3.9 Double compression type nickel plated (coating thickness not less than 10 microns) brass cable glands shall be provided by the Contractor for all power and control cables to provide dust and weather proof terminations.

13.3.10 They shall comprise of heavy duty brass casting, machine finished and nickel plated, to avoid corrosion and oxidation. Rubber components used in cable glands shall be neoprene and of tested quality. Cable glands shall be of approved make.

13.3.11 The cable glands shall also be suitable for dust proof and weather proof termination. The test procedure, if required, has to be discussed and agreed to between Owner and cable gland manufacturer.

13.3.12 If the cable-end box or terminal enclosure provided on the equipment is found unsuitable and requires modification, the same shall be carried out by the Contractor, as directed by the Owner.

13.3.13 Crimping tool used shall be of approved design and make.

13.3.14 Cable lugs shall be tinned copper solderless crimping type conforming to relevant international standard. Bimetallic lugs shall be used depending upon type of cables used.

13.3.15 Solderless crimping of terminals shall be done by using corrosion inhibitory compound. The cable lugs shall suit the type of terminals provided.

13.4 **STORAGE AND HANDLING OF CABLE DRUMS**

13.4.1 Cable drums shall be unloaded, handled and stored in an approved manner and rolling of drums shall be avoided as far as possible. For short distances, the drums may be rolled provided they are rolled slowly and in proper direction as marked on the drum.

14.0 **DIRECTLY BURIED CABLES**

14.1 The Contractor shall construct the cable trenches required for directly buried cables. The scope of work shall include excavation, preparation of sand bedding, soil cover, supply and installation of brick or concrete protective covers, back filling and ramming, supply and installation of route markers and joint markers. The Bidder shall ascertain the soil conditions prevailing at site, before submitting the bid.

14.2 The cable (power and control) between LT station, control room and fire lighting pump house shall be laid in the buried cable trenches. In addition to the above, for lighting purpose also, buried cable trench can be used in outdoor area.

14.3 Cable route and joint markers and RCC warning covers shall be provided wherever required. The voltage grade of cables shall be engraved on the marker.

15.0 **INSTALLATION OF CABLES**

15.1 Cabling in the control room shall be done on ladder type cable trays for vertical runs while cabling in switchyard area shall be done on angles in the trench.

15.2 All cables from bay cable trench to equipment's including and all interpole cables (both power and control) for all equipment, shall be laid in PVC pipes of minimum 50 mm nominal outside diameter which shall be buried in the ground at a depth of 250mm below finish formation level. Separate PVC pipes shall be laid for control and power cables. Cable pull boxes of adequate size shall be provided if required.

15.3 Cables shall be generally located adjoining the electrical equipment through the pipe insert embedded in the floor. In the case of equipments located away from cable trench either pipe inserts shall be embedded in the floor connecting the cable trench and the equipment or in case the distance is small, notch/opening on the wall shall be provided. In all these cases necessary bending radius as recommended by the cable manufacturer shall be maintained.

15.4 Cable racks and supports shall be painted after installation with two coats of metal primer (comprising of red oxide and zinc chromate in a synthetic medium) followed by two finishing coats of aluminium paint.

15.5 Suitable arrangement should be used between fixed pipe / cable trays and equipment terminal boxes, where vibration is anticipated.

15.6 Power and control cables in the cable trench shall be laid in separate tiers. The order of laying of various cables shall be as follows, for cables other than directly buried.

a) Power cables on top tiers.

b) Control instrumentation and other service cables in bottom tiers.

15.7 Single core cables in trefoil formation shall be laid with a distance of three times the diameter of cable between trefoil centre lines. All power cables shall be laid with a minimum centre to centre distance equal to twice the diameter of the cable of higher size of cables.

15.8 Trefoil clamps for single core cables shall be of pressure die cast aluminium (LM-6), Nylon -6 or fibre glass and shall include necessary fixing GI nuts, bolts, washer etc. These are required at every 2 metre of cable runs.

15.9 Power and control cables shall be securely fixed to the trays/supports with self locking type nylon ties with deinterlocking facility at every 5 metre interval for horizontal run. Vertical and inclined cable runs shall be secured with 25 mm wide and 2 mm thick aluminium strip clamps at every 2m.

15.10 Cables shall not be bent below the minimum permissible limit. The permissible limits are as follows:

Table of Cable and	Minimum bending radius
Power cable	12 D
Control cable	10 D

D is overall diameter of cable

15.11 Where cables cross roads, drains and rail tracks, these shall be laid in reinforced spun concrete or steel pipes buried at not less than one metre depth.

15.12 In each cable run some extra length shall be kept at a suitable point to enable one (for LT cables)/two (for H.T. cables) straight through joints to be made in case the cable develop fault at a later date.

15.13 Selection of cable drums for each run shall be so planned as to avoid using straight through joints. Cable splices will not be permitted except where called for by the drawings, unavoidable or where permitted by the Owner. If straight through joints are unavoidable, the Contractor shall use the straight through joints kit of reputed make.

15.14 Control cable terminations inside equipment enclosures shall have sufficient lengths so that changing of termination in terminal blocks can be done without requiring any splicing.

15.15 Metal screen and armour of the cable shall be bonded to the earthing system of the station, wherever required by the Owner.

15.16 Rollers shall be used at intervals of about two metres while pulling cables.

15.17 All due care shall be taken during unreeling, laying and termination of cable to avoid damage due to twist, kinks, sharp bends, etc.

15.18 Cable ends shall be kept sealed to prevent damage. In cable vault, fire resistant seal shall be provided underneath the panels.

15.19 Inspection on receipt, unloading and handling of cables shall generally be in accordance with relevant international standard.

15.20 Wherever cable pass through floor or through wall openings or other partitions, GI/PVC wall sleeves with bushes having a smooth curved internal surface so as not to damage the cable, shall be supplied, installed and properly sealed by the Contractor at no extra charges.

15.21 Contractor shall remove the RCC/Steel trench covers before taking up the work and shall replace all the trench covers after the erection-work in that particular area is completed or when further work is not likely to be taken up for some time.

15.22 Contractor shall furnish three copies of the report on work carried out in a particular week, indicating cable numbers, date on which laid, ual length and route, testing carried out, terminations carried out, along with the marked up copy of the cable schedule and interconnection drawing wherever any modifications are made.

15.23 Contractor shall paint the tray identification number on each run of trays at an interval of 10 m.

15.24 In case the outer sheath of a cable is damaged during handling/installation, the Contractor shall repair it at his own cost to the satisfaction of the Owner. In case any other part of a cable is damaged, the same shall be replaced by a healthy cable at no extra cost to the Owner, i.e. the Contractor shall not be paid for installation and removal of the damaged cable.

15.25 All cable terminations shall be appropriately tightened to ensure secure and reliable connections. The Contractor shall cover the exposed part of all cable lugs whether supplied by him or not with insulating tape, sleeve or paint.

15.26 **Cable trays**

i) The cable trays shall be of G.S.sheet and minimum thickness of sheet shall be 2mm.

ii) The Contractor shall perform all tests and inspection to ensure that material and workmanship are according to the relevant standards.

A 2.5 metre straight section of 300mm, 600mm wide cable tray shall be simply supported at two ends. A uniform distributed load of 76 kg/m shall be applied along the length of the tray. The maximum deflection at the mid-span shall not exceed 7mm.

15.27 **Conduits, Pipes and Duct Installation**

15.27.1 Contractor shall supply and install all rigid conduits, mild steel pipes,flexible conduits, hume pipes etc. including all necessary sundry materials such as tees, elbows, check nuts, bushing, reducers, enlargers, coupling cap, nipples, gland sealing fittings, pull boxes etc as specified and to be shown in detailed drawing. The size of the conduit/pipe shall be selected on the basis of 40% fill criterion.

15.27.2 Contractor shall have his own facility for bending, cutting and threading the conduits at site. Cold bending should be used. All cuts & threaded ends shall be made smooth without leaving any sharp edges. Anticorrosive paint shall be applied at all field threaded portions.

15.27.3 All conduit/pipes shall be extended on both sides of wall/floor openings. The fabrication and installation of supports and the clamping shall be included in the scope of work by Contractor.

15.27.4 When two lengths of conduits are joined together through a coupling, running threads equal to twice the length of coupling shall be provided on each conduit to facilitate easy dismantling of two conduits.

15.27.5 Conduit installation shall be permanently connected to earth by means of special approved type of earthing clamps. GI pull wire of adequate size shall be laid in all conduits before installation.

15.27.6 Each conduit run shall be painted with its designation as indicated on the drawings such that it can be identified at each end.

15.27.7 Embedded conduits shall have a minimum concrete cover of 50 mm.

15.27.8 Conduit run sleeves shall be provided with the bushings at each end.

15.27.9 Metallic conduit runs at termination shall have two locknuts and a bushing for connection. Flexible conduits shall also be suitably clamped at each end with the help of bushings. Bushings shall have rounded edges so as not to damage the cables.

15.27.10 Where embedded conduits turn upwards from a slab or fill, the termination dimensions shown on the drawings, if any, shall be taken to represent the position of the straight extension of the conduit external to and immediately following the bend. At least one half of the arc length of the bend shall be embedded.

15.27.11 All conduits/pipes shall have their ends closed by caps until cables are pulled. After cables are pulled, the ends of conduits/pipes shall be sealed in an approved manner to prevent damage to threaded portions and entrance of moisture and foreign material.

15.27.12 For underground runs, Contractor shall excavate and back fill as necessary.

15.27.13 Contractor shall supply, unload, store and install conduits required for the lighting installation as specified. All accessories/fittings required for making the installation complete, including but not limited to pull out boxes, ordinary and inspection tees and elbow, checknuts, male and female bushings (brass or galvanised steel), caps, square headed male plugs, nipples, gland sealing fittings ,pull boxes, conduits terminal boxes, gaskets and box covers, saddle terminal boxes, and all steel supporting work shall be supplied by the Contractor. The conduit fittings shall be of the same material as conduits.

15.27.14 All unarmoured cables shall run within the conduits from lighting panels to lighting fixtures, receptacles etc.

15.27.15 Size of conduit for lighting shall be selected by the Contractor during detailed engineering.

15.27.16 Exposed conduits shall be run in straight lines parallel to building columns, beams and walls. Unnecessary bends and crossings shall be avoided to present a neat appearance.

15.27.17 Conduit supports shall be provided at an interval of 750mm for horizontal runs and 1000mm for vertical runs.

15.27.18 Conduit supports shall be clamped on the approved type spacer plates or brackets by saddles or U- bolts. The spacer plates or brackets in turn, shall be securely fixed to the building steel by welding and to concrete or brick work by grouting or by nylon rawl plugs. Wooden plug inserted in the masonary or concrete for conduit support is not acceptable.

15.27.19 Embedded conduits shall be securely fixed in position to preclude any movement. In fixing embedded conduit, if welding or brazing is used, extreme care should be taken to avoid any injury to the inner surface of the conduit.

15.27.20 Spacing of embedded conduits shall be such as to permit flow of concrete between them.

15.27.21 Where conduits are placed alongwith cable trays, they shall be clamped to supporting steel at an interval of 600mm.

15.27.22 For directly embedding in soil, the conduits shall be coated with an asphalt-base compound. Concrete pier or anchor shall be provided wherever necessary to support the conduit rigidly and to hold it in place.

15.27.23 Conduit shall be installed in such a way as to ensure against trouble from trapped condensation.

15.27.24 Conduits shall be kept, wherever possible, at least 300mm away from hot pipes, heating devices etc. when it is evident that such proximity may reduce the service life of cables.

15.27.25 Slip joints shall be provided when conduits cross structural expansion joints or where long run of exposed conduits are installed, so that temperature change will cause no distortion due to expansion or contrion of conduit run.

15.27.26 For long conduit run, pull boxes shall be provided at suitable intervals to facilitate wiring.

15.27.27 Conduit shall be securely fastened to junction boxes or cabinets, each with a lock nut inside and outside the box.

15.27.28 Conduits joints and connections shall be made thoroughly water-tight and rust proof by application of a thread compound which insulates the joints. White lead is suitable for application on embedded conduit and red lead for exposed conduit.

15.27.29 Field bends shall have a minimum radius of four (4) times the conduit diameter. All bends shall be free of kinks, indentations of flattened surfaces. Heat shall not be applied in making any conduit bend. Separate bends may be used for this purpose.

15.27.30 The entire metallic conduit system, whether embedded or exposed, shall be electrically continuous and thoroughly grounded. Where slip joints are used, suitable bounding shall be provided around the joint to ensure a continuous ground circuit.

15.27.31 After installation, the conduits shall be thoroughly cleaned by compressed air before pulling in the wire.

15.27.32 Lighting fixtures shall not be suspended directly from the junction box in the main conduit run.

16.0 JUNCTION BOX

a) The Contractor shall supply and install junction boxes complete with terminals as required. The brackets, bolts, nuts, screws etc required for erection are also included in the scope of the Contractor.

b) Junction boxes having volume less than 1600 cubic centimeters may be installed without any support other than that resulting from connecting conduits where two or more rigid metallic conduits enter and accurately position the box. Boxes shall be installed so that they are level, plumb and properly aligned to present a pleasing appearance.

c) Boxes with volumes equal to or greater than 1600 cubic cm, and smaller boxes terminating on less than two rigid metallic conduits or for other reasons not rigidly held, shall be adequately supported by auxiliary steel of standard steel shapes or plates to be fabricated and installed. The Contractor shall perform all drilling, cutting, welding, shimming and bolting required for attachment of supports.

17.0 TESTING AND COMMISSIONING

17.1 An indicative list of tests for testing and commissioning is given below. Contractor shall perform any additional test based on specialities of the items as per the field Q.P./instructions of the equipment Contractor or Owner without any extra cost to the Owner. The Contractor shall arrange all equipments instruments and auxiliaries required for testing and commissioning of equipments alongwith calibration certificates and shall furnish the list of instruments to the Owner for approval.

17.2 **GENERAL CHECKS**

(a) Check for physical damage.

(b) Visual examination of zinc coating/plating.

(c) Check from name plate that all items are as per order/specification.

(d) Check tightness of all bolts, clamps and connecting terminals using torque wrenches.

(e) For oil filled equipment, check for oil leakage, if any. Also check oil level and top up wherever necessary.

(f) Check ground connections for quality of weld and application of zinc rich paint over weld joint of galvanised surfaces.

(g) Check cleanliness of insulator and bushings.

(h) All checks and tests specified by the manufacturers in their drawings and manuals as well as all tests specified in the relevant code of erection.

(i) Check for surface finish of grading rings (Corona control ring).

(j) Pressure test on all pneumatic lines at 18.5 times the rated pressure shall be conducted.

17.3 **STATION EARTHING**

a) Check soil resistivity

b) Check continuity of grid wires

c) Check earth resistance of the entire grid as well as various sections of the same.

d) Check for weld joint and application of zinc rich paint on galvanised surfaces.

e) Dip test on earth conductor prior to use.

17.4 **AAC/ACSR STRINGING WORK, TUBULAR BUS WORK AND POWER CONNECTORS**

a) Physical check for finish

b) Electrical clearance check

c) Testing of torque by torque wrenches on all bus bar power connectors and other accessories.

d) Millivolt drop test on all power connectors.

e) Sag and tension check on conductors.

17.5 **ALUMINIUM TUBE WELDING**

a) Physical check

b) Millivolt drop test on all joints.

c) Dye penetration test & Radiography test on 10% sample basis on weld joints.

c) Test check on 5% sample joints after cutting the weld piece to observe any voids etc.

17.6 INSULATOR

Visual examination for finish, damage, creepage distance etc.

17.7 All pre/commissioning invitees and works for substation equipment shall be carried out in accordance with owner's ''Pre- Commissioning procedures and formats for substation bay equipments" by the contractor. This document shall be provided to the successful contractor during detailed engineering stage.

ANNEXURE-A

STANDARD TECHNICAL DATA SHEETS FOR AAC/ACSR CONDUCTORS, GS EARTHWIRE AND ALUMINIUM TUBE

1.0 GENERAL

Owner has stardardised the guaranteed technical particulars for the following AAC/ACSR conductors, Galvanised steel earthwire and aluminum tube. The contractor shall supply the conductors as per the standard GTP mentioned below. Any deviation to the following GTP shall be clearly brought out by the bidder in their bid.

1.1 Guaranteed Technical Particulars (GTP) for conductors:

A. GTP of ACSR MOOSE conductor:

Sl.	**Description**	**Unit**	**ACSR MOOSE**
1.0	**Applicable Standard**	IEC-61089	
2.0	**Raw Materials**		
2.1	Aluminium		
a)	Minimum purity of Aluminium	%	99.50
b)	Maximum copper content	%	0.04
2.2	Steel wires/ rods		
a)	Carbon	%	0.50 to 0.85
b)	Manganese	%	0.50 to 1.10
c)	Phosphorous	%	Not more than 0.035
d)	Sulphur	%	Not more than 0.045
e)	Silicon	%	0.10 to 0.35 (Max.)
2.3	Zinc		
a)	Minimum purity of Zinc	%	99.95
3.0	**Aluminium strands after stranding**		
3.1	Diameter		
a)	Nominal	mm	3.53
b)	Maximum	mm	3.55
c)	Minimum	mm	3.51
3.2	Minimum Breaking load of strand		
a)	Before stranding	KN	1.57
b)	After stranding	KN	1.49
c)	*Maximum D.C. resistance of strand at 20 deg. Centigrade*	*Ohm /KM*	*2.921*
3.3	Maximum resistance of 1 m length of strand at 20 deg. C	Ohm	0.002921
4.0	**Steel strand after stranding**		
4.1	Diameter		
a)	Nominal	mm	3.53

Sl.	Description	Unit	ACSR MOOSE
1.0	**Applicable Standard**	IEC-61089	
2.0	**Raw Materials**		
2.1	Aluminium		
b)	Maximum	mm	3.60
c)	Minimum	mm	3.46
4.2	Minimum Breaking load of strand		
a)	Before stranding	KN	12.86
b)	After stranding	KN	12.22
4.3	Galvanising		
a)	Minimum weight of zinc coating per sq.m.	gm	260
b)	Minimum number of dips that the galvanised strand can withstand in the standard preece test	Nos.	2 dips of one minute & 1 dip of half minute
c)	Min. No. of twists in guage length equal 100 times the dia. of wire which the strand can withstand in the torsion test (after stranding)	Nos	16 (After stranding) 18 (Before stranding)
5.0	ACSR Conductor		
5.1.a)	Stranding		Al -54/3.53 mm+ Steel-7/3.53 mm
b)	Number of Strands		
i.	Steel centre	Nos.	1
ii.	1st Steel Layer	Nos.	6
iii.	1st Aluminium Layer	Nos.	12
iv.	2nd Aluminium Layer	Nos.	18
v.	3rd Aluminium Layer	Nos.	24
5.2	Sectional Area of aluminium	Sq. mm	528.50
5.3	Total sectional area	Sq. mm	597.00
5.4	Approximate Weight	Kg/m	2.004
5.5	Diameter of the conductor	mm	31.77
5.6	UTS of the conductor	kN	161.20 (Min.)
5.7	Lay ratio of the conductor	mm	Max Min
a)	Outer Steel layer	mm	18 16
b)	8/12 wire Aluminium layer	mm	14 12
c)	14/ 18 wire Aluminium layer	mm	13 11
d)	20/24 wire Aluminium layer	mm	12 10

Sl.	Description	Unit	ACSR MOOSE
1.0	**Applicable Standard**	IEC-61089	
2.0	**Raw Materials**		
2.1	Aluminium		
5.8	DC resistance of the conductor at 20°C	ohm/km	0.05552
5.9	Standard length of the conductor	m	1800
5.10	Tolerance on Standard length	%	(+/-) 5
5.11	Direction of lay of outer layer	-	Right Hand
5.12	Linear mass of the conductor		
a)	Standard	kg/km	2004
b)	Minimum	kg/km	1965
c)	Maximum	kg/km	2045
5.13	Modulus of Elasticity (Final State)	Kg/sq.mm	6860
5.14	Co-efficient of Linear Expansion	Per Deg. C	$19.3x10^{-6}$
5.15	Minimum Corona Extinction Voltage	KV (rms)	320
5.16	RIV at 1 Mhz under dry condition	Microvolts	Max. 1000 at 320 kV (rms)
6.0	**Drum Dimensions**		
a)	Flange Diameter	mm	1800
b)	Traverse width	mm	950
c)	Barrel Diameter	mm	650
d)	Flange thickness	mm	50x50

1.2 Guaranteed technical particulars of Galvanised Steel Earthwire

	Description	Unit	Standard Values
1.0	**Raw Materials**		
1.1	**Steel wires / rods**		
a)	Carbon	%	Not more than 0.55
b)	Manganese	%	0.40 to 0.90
c)	Phosphorous	%	Not more than 0.04
d)	Sulphur	%	Not more than 0.04
e)	Silicon	%	0.15 to 0.35

1.2	**Zinc**		
a)	Minimum purity of Zinc	%	99.95
2.0	**Steel strands**		
2.1	**Diameter**		
a)	Nominal	mm	3.66
b)	Maximum	mm	3.74
c)	Minimum	mm	3.58
2.2.	**Minimum breaking load of strand**		
a)	After stranding	KN	10.58
2.3	**Galvanising**		
a)	Minimum weight of zinc coating per sq.m. after stranding	gms.	275
b)	Minimum number of dips that the galvanized strand can withstand in the standard preece test	Nos.	3 dips of 1 minute and one dip of ½ minute
c)	Minimum number of twists in a gauge length equal to 100 times diameter of wire which the strand can withstand in the torsion test, after stranding	Nos.	18
3.0	**Stranded Earth wire**		
3.1	**UTS of Earth wire**	KN	68.4 (min.)
3.2	**Lay length of outer steel layer**		
a)	Standard	mm	181
b)	Maximum	mm	198
c)	Minimum	mm	165
3.3	**Maximum DC resistance of earth wire at 20^0 C**	Ohm/km	3.375
3.4	**Standard length of earth wire**	M	2000 or ual quantity whichever is less.
3.5	**Tolerance on standard length**	%	±5
3.6	**Direction of lay for outside layer**		Right hand
3.7	**Linear mass**		

a)	Standard	Kg/km	583
b)	Maximum	Kg/km	552
c)	Minimum	Kg/km	600
3.8	**Overall diameter**	mm	10.98

1.3 Guaranteed Technical Parameters of Aluminum Tube

A. GTP for 3" IPS & 4" IPS AL. TUBE

Sl. No.	Description	3" AL. TUBE	4" AL. TUBE
1.	Size	3" IPS (EH Type)	4" IPS (EH Type)
2.	Material	Aluminium Alloy 6101 T6 confirms to relevant international standard.	
3.	Chemical Composition		
i)	Cu	0.05 Max	
ii)	Mg	0.4 to 0.9	
iii)	Si	0.3 to 0.7	
iv)	Fe	0.5 Max	
v)	Mn	0.03 Max	
Vi)	Al	Remainder	
4.	Outer diameter	88.90 mm	114.2 mm
5.	Tolerance on outer diameter	*+2.2 mm, - 0.0 mm*	*+2.2 mm, - 0.0 mm*
6.	Thickness	7.62 mm	8.51 mm
7.	Tolerance on thickness	*+2.2 mm, - 0.0 mm*	*+2.2 mm, - 0.0 mm*
8.	Cross-sectional area	1945.76 sq.mm	2825.61 sq.mm
9.	Weight	5.25 kg/m	7.7 kg/m
10.	Moment of Inertia	*1621589.99 mm^4*	*3972577.97 mm^4*
11.	Section Modulus	*36481.21 mm^3*	*69572.29 mm^3*
12.	Minimum Ultimate Tensile Strength	20.5 Kg/sq.mm	
13.	Temperature co-efficient of resistance	0.00364 per Deg.C	
14.	Minimum Electrical Conductivity at 20 deg.C	55% of IACS	
15.	Linear Temperature Co-efficient of Expansion (20 Deg.C -200 Deg.C)	0.000023	
16.	Modulus of Elasticity	6700 Kg/sq.mm	
17.	Minimum Elongation on 50 mm	10%	
18.	Thermal Conductivity at 100 Deg.C	0.43 Calories/sec/sq.mm/cm/deg.C	
19.	Minimum 0.2% proof stress	17.34 Kg/sq.mm	
20	Minimum Yield point	17.50 Kg/sq.mm	17.50 Kg/sq.mm
21	Minimum Breaking Strength	20.42 Kg/sq.mm	20.42 Kg/sq.mm

B. GTP for 4.5" IPS & 5" IPS AL. TUBE

Sl. No.	Description	4.5" AL. TUBE	5" AL. TUBE
1.	Size	4.5" IPS (EH Type)	5" IPS
2.	Material	Aluminium Alloy 6101 T6 confirms to relevant international standard.	
3.	Chemical Composition		
i)	Cu	0.05 Max	
ii)	Mg	0.4 to 0.9	
iii)	Si	0.3 to 0.7	
iv)	Fe	0.5 Max	
v)	Mn	0.03 Max	
Vi)	Al	Remainder	
4.	Outer diameter	120.0 mm	141.3 mm
5.	Tolerance on outer diameter	+1.5 mm, - 0.0 mm	+2.8 mm, - 0.0 mm
6.	Thickness	12.0 mm	9.53 mm
7.	Tolerance on thickness	+1.0 mm, - 0.0 mm	+0.8 mm, - 0.0 mm
8.	Cross-sectional area	4071.50 sq.mm	3945.11 sq.mm
9.	Weight	10.993 kg/m	10.652 kg/m
10.	Moment of Inertia	6011958.58 mm^4	8610787.65 mm^4
11.	Section Modulus	100199.31 mm^3	121879.51 mm^3
12.	Minimum Ultimate Tensile Strength	20.5 Kg/sq.mm	
13.	Temperature co-efficient of resistance	0.00364 per Deg.C	
14.	Minimum Electrical Conductivity at 20 deg.C	55% of IACS	
15.	Linear Temperature Co-efficient of Expansion (20 Deg.C -200 Deg.C)	0.000023	
16.	Modulus of Elasticity	6700 Kg/sq.mm	
17.	Minimum Elongation on 50 mm	10%	
18.	Thermal Conductivity at 100 Deg.C	0.43 Calories/sec/sq.mm/cm/deg.C	
19.	Minimum 0.2% proof stress	17.34 Kg/sq.mm	
20	Minimum Yield point	14.50 Kg/sq.mm	17.50 Kg/sq.mm
21	Minimum Breaking Strength	17.50 Kg/sq.mm	20.42 Kg/sq.mm

1.4 Guaranteed Technical Parameters of 220 kV Bus Bar Conductor Thermal-resistant aluminum alloy conductor steel reinforced

Item		Unit	Data
Code Name		Thermal-resistant aluminum alloy conductor steel reinforced 1000/125	
Surface quality		The conductor shall be clean and free of imperfections not consistent good commercial practice	

Item		Unit	Data
Structure	Aluminium	(no./Dia.mm)	54/4.84
	Steel	(no./Dia.mm)	19/2.90
Area	Total	mm2	1119
	Aluminium	mm2	993.5
	Steel	mm2	125.5
Overall Dia.		mm	43.5
Mass		kg/km	2987.8
Max. DC resistance at 20 deg Centigrade		Ω/km	≤0.0296
Nominal Breaking Load		kN	≥301.0
Elasticity modulus		GPa	70.14
Coefficient of linear expansion		1/°C	19.5x10-6
Lay Ratio	6 Steel Layer		16-22
	12 Steel layer		14-20
	Aluminium inner layer		10-16
	Aluminium adjacent outer layer		10-16
	Aluminium outer layer		10-12
Properties of Steel			
Dimeter		mm	2.9
Tension strength	before strand	Mpa	≥1310
	after strand	Mpa	≥1245
Stress at 1% extension		Mpa	≥1100

ANNEXURE – B

A. SHORT CIRCUIT FORCES AND SPACER SPAN FOR 400kV GANTRY STRUCTURE

Sl. No.	Max. Span	Conductor Configuration	Ph-Ph Spacing	Normal Tension	SCF per Phase	Spacer span
I.	**For Fault Level of 40 kA for 1 sec.**					
1.	54 mtr	QUAD ACSR	7 mtr	4 T	5.64 T	6 mtr
2.	70 mtr	TWIN ACSR	7 mtr	4 T	5.64 T	5 mtr
3.	54 mtr	QUAD ACSR	6 mtr	4 T	5.10 T	5 mtr
4.	70 mtr	TWIN ACSR	6 mtr	4 T	5.10 T	5 mtr
5.	48 mtr	QUAD ACSR	6 mtr	4 T	4.82T	5 mtr
6.	52.5 mtr	QUAD ACSR	6 mtr	4 T	4.85T	5 mtr
7.	56.5 mtr	QUAD ACSR	6 mtr	4 T	4.88T	5 mtr
8.	52.5 mtr	TWIN ACSR	6 mtr	4 T	4.97T	5 mtr
9.	56.5 mtr	TWIN ACSR	6 mtr	4 T	5.00 T	5 mtr
II.	**For Fault Level of 50 kA for 1 sec.**					
1.	48 mtr	QUAD AAC BULL	6 mtr	4 T	5.10 T	4 mtr
2.	52.5 mtr	QUAD ACSR	6 mtr	4 T	5.18 T	4 mtr
3.	56.5 mtr	QUAD ACSR	6 mtr	4 T	5.20 T	4 mtr
III.	**For Fault Level of 63 kA for 1 sec.**					
1.	48 mtr	QUAD AAC BULL	6 mtr	4 T	6.00 T	4 mtr
2.	52.5 mtr	QUAD ACSR	6 mtr	4 T	6.33 T	4 mtr
3.	56.5 mtr	QUAD ACSR	6 mtr	4 T	6.37 T	4 mtr

B. SHORT CIRCUIT FORCES AND SPACER SPAN FOR 220 kV GANTRY STRUCTURE

Sl. No.	Max. Span	Conductor Configuration	Ph-Ph Spacing	Normal Tension	SCF per Phase	Spacer span
I.	**For Fault Level of 40 kA for 1 sec.**					
1.	54 mtr	QUAD ACSR	4.5 mtr	4 T	5.00 T	2.5 mtr
2.	54 mtr	TWIN ACSR	4.5 mtr	2 T	3.50 T	2.5 mtr
3.	74 mtr	TWIN ACSR	4.5 mtr	4 T	5.00 T	2.5 mtr
4.	54 mtr	QUAD ACSR	4.0 mtr	4 T	5.70 T	2.5 mtr
5.	54 mtr	TWIN ACSR	4.0 mtr	2 T	3.50 T	2.5 mtr
6.	74 mtr	TWIN ACSR	4.0 mtr	4 T	5.70 T	2.5 mtr
7.	48 mtr	QUAD ACSR	4.0 mtr	4 T	5.30 T	2.5 mtr
8.	52 mtr	QUAD ACSR	4.0 mtr	4 T	5.35 T	2.5 mtr
9.	68 mtr	TWIN ACSR	4.0 mtr	4 T	5.20 T	2.5 mtr
10.	56 mtr	QUAD ACSR	4.0 mtr	4 T	5.50 T	2.5 mtr
11.	72 mtr	TWIN ACSR	4.0 mtr	4 T	5.27 T	2.5 mtr
II.	**For Fault Level of 50 kA for 1 sec.**					
1.	48 mtr	QUAD ACSR	4.0 mtr	4 T	5.41 T	2.0 mtr
2.	52 mtr	QUAD ACSR	4.0 mtr	4 T	5.50 T	2.0 mtr
3.	36 mtr	TWIN ACSR	4.0 mtr	2 T	3.50 T	2.0 mtr

NOTE: ACSR conductor as mentioned above indicates that it is suitable for both ACSR MOOSE as well as ACSR BERSIMIS conductor.

C. SHORT CIRCUIT FORCES AND SPACER SPAN FOR 132 kV GANTRY STRUCTURE

Sl. No.	Max. Span	Conductor Configuration	Ph-Ph Spacing	Normal Tension	SCF per Phase	Spacer span
I.	**For Fault Level of 31.5kA for 1 sec.**					
1.	36 mtr	Twin Moose/ Zebra ACSR	3 mtr	1 T	2.15 T	2.5 mtr
2.	31.5 mtr	Twin Moose/ Zebra ACSR	2.7mtr	1 T	2.15 T	2.5 mtr
3.	48 mtr	Single Moose/ Zebra ACSR	3 mtr	1 T	2.05 T	NA
4.	42 mtr	Single Moose/ Zebra ACSR	2.7 mtr	1 T	2.03 T	NA

CHAPTER 15: STRUCTURE

1.0 GENERAL

The scope of specification covers design, fabrication, trial assembly, supply and erection of galvanized steel structures for towers, girders, lightning masts and equipment support structures. Structures shall be lattice or Pipe type structure (as per Chapter 1-PSR) fabricated from structural steel conforming to relevant British standard Codes (BS Codes)/ Indian Standard Codes (IS Codes)/equivalent International Standards.

The line diagram of all structures of 400kV, 220 kV, 132kV and 33 kV for switch yards shall be prepared by the contractor based on their design during detailed engineering stage. The fabrication drawing/line diagram of structures for extension of existing switch yards shall be furnished by NEA to the successful bidder progressively during detailed engineering stage. The bidder shall mention in their bid for the type of proposed structure i.e. Pipe or lattice type structure. The fabrication drawings, proto corrected drawings along with Bill of Material (BOM) for all the structures (Both Gantry and Equipment support structures) shall be prepared by the contractor during detailed engineering for submission to NEA for their approval. Support structure for circuit breaker shall also be designed by the Manufacturer/Contractor.

It is the intent of the NEA to provide structures which allow interchangeability of equipments at a later stage. Accordingly, Contractor is expected to design the equipment support structures with the provision of stool. Stools shall be provided by the Contractor between the equipment and its support structure to match the bus bar height. The top of stool shall be connected to the equipment and the bottom of the stool shall be connected to the Base support structure.

The scope shall include supply and erection of all types of structures including bolts, nuts, washers, step bolts, inserts in concrete, gusset plates, equipment mounting bolts, structure earthing bolts, foundation bolts, spring washers, fixing plates, ground mounted marshalling boxes (AC/DC Marshalling box & equipment control cabinets), structure mounted marshalling boxes and any other items as required to complete the job.

The connection of all structures to their foundations shall be with base plates and embedded anchor/foundation bolts. All steel structures and anchor/foundation bolts, fasteners (Nuts, bolts, washers) shall be fully galvanized as per relevant British standard Codes (BS Codes) / equivalent International Standards. The weight of the zinc coating shall be at least

610 grammes /sq. m for anchor bolts/foundation bolts and for structural members. One additional nut shall be provided below the base plate which may be used for the purpose of leveling.

Contractor shall provide suitable arrangement on the equipment support structures wherever required to suit fixation of accessories such as marshalling boxes, MOM boxes, Control Cabinets, Junction box, surge counter, etc. in the equipment structure fabrication drawings.

2.0 DESIGN REQUIREMENTS FOR STRUCTURES

2.1 For design of steel structures loads such as dead loads, live loads, wind loads etc. shall be based on relevant British standard Codes (BS Codes)/ Indian Standard Codes (IS Codes)/equivalent International Standards.

2.2 For materials and permissible stresses, relevant British standard Codes (BS Codes) / equivalent International Standards. Shall be followed in general. However, additional requirements given in following paragraphs shall be also considered.

2.3 Minimum thickness of galvanized lattice structure member shall be as follows:

Members Min Thickness	(mm)
Leg members, Ground wire	5
Peak members\/Main members	5
Other members	4
Redundant members	

2.4 Maximum slenderness ratios for leg members, other stressed members and redundant members for compression force shall be as per relevant British standard Codes (BS Codes)/equivalent International Standards.

2.5 Minimum distance from hole center to edge shall be 1.5 x bolt diameter. Minimum distance between center to center of holes shall be 2.5 x bolt diameter.

2.6 All bolts shall be M16 or higher as per design requirement.

2.7 **Step Bolts**

In order to facilitate inspection and maintenance, the tower structures shall be provided with climbing devices. Each tower shall be provided with M16 step bolts 175mm long spaced not more than 450mm apart, staggered on faces on diagonally opposite legs extending from about 0.5 meters above plinth level to the top of the tower. The step bolt shall conform to relevant British standard Codes (BS Codes)/ Indian Standard Codes (IS Codes)/equivalent International Standards. Ladders along with safety guard shall be provided for the Lightning Mast Tower.

2.8 **Design Criteria**

a) All gantry structures shall be designed for the worst combination of dead loads, live loads, wind loads and Seismic forces as per relevant British standard Codes (BS Codes)/ Indian Standard Codes (IS Codes)/equivalent International Standards (latest), loads due to deviation of conductor, load due to unbalanced tension in conductor, torsional load due to unbalanced vertical and horizontal forces, erection loads, short circuit forces including "snatch" in the case of bundled conductors etc. Short circuit forces shall be calculated considering a fault level of 50.0 kA for 400kV, 40.0 kA for 220kV, 31.5KA for 132kV and 25KA for 33kV or as applicable. Relevant British standard Codes (BS Codes)/ Indian Standard Codes (IS Codes)/equivalent International Standards may be followed for evaluation of short circuit forces.

b) Switchyard gantry structures shall be designed for the two conditions i.e. normal condition and short circuit condition. In both conditions the design of all structures shall be based on the assumption that stringing is done only on one side i.e. all the three (phase) conductors broken on the other side.

Factor of safety of 2.0 under normal conditions and 1.5 under short circuit condition shall be considered on all external loads for the design of switchyard structures.

c) Vertical load of half the span of conductors/string and the earth wires on either side of the beam shall be taken into account for the purpose of design. Weight of man with tools shall be considered as 150 kgs. for the design of structures.

d) Terminal/line take off gantries shall be designed for a minimum conductor tension of 4 metric tonnes per phase for 400 kV, 2 metric tonnes per phase for 220 kV, 1 Metric tonne per phase for 132 kV and 0.50 Metric Tonne for 33 kV or as per requirements whichever is higher. The distance between terminal gantry and dead end tower shall be taken as 200 meters for 400/220kV, 150m for 132kV and 80 m for 33 kV switch yard. The design of these terminal gantries shall also be checked considering +/- 30 deg. deviation of conductor in both vertical and horizontal planes. For other gantries the structural layout requirements shall be adopted in design.

e) The girders / beams shall be connected with lattice/Tower columns by bolted joints.

f) All equipment support structures shall be designed for the worst combination of dead loads, erection load. Wind load/seismic forces, short circuit forces and operating forces acting on the equipment and associated bus bars as per relevant British standard Codes (BS Codes)/ Indian Standard Codes (IS Codes)/equivalent International Standards.

g) If luminaries are proposed to be fixed on gantries/towers, then the proper loading for the same shall be considered while designing. Also holes for fixing the brackets for luminaries should be provided wherever required.

h) Foundation bolts shall be designed for the loads for which the structures are designed.

i) The height of Lightning Mast shall be as per approved structural layout and designed for diagonal wind condition. The lightning mast shall be provided with platform for mounting of lighting fixtures and a structural steel ladder within its base up to the level of platform. The ladder shall be provided with protection rings. The platforms shall also have protection railing. The details of lighting fixtures would be as per approved drawings of electrical fixtures.

3.0 DESIGN, DRAWINGS, BILL OF MATETRIALS AND DOCUMENTS

3.1 The Contractor shall submit design and line diagram of each structure for approval of NEA. Fabrication drawing based on approved line diagram shall be prepared by the contractor for approval of NEA. The BOM (Bill of Material) shall be prepared by the contractor based on approved fabrication drawing. The Line diagram should indicate not only profile, but section, numbers and sizes of bolts and details of typical joints. In case NEA feels that any design or drawings are to be modified even after its approval, Contractor shall modify the designs & drawings and resubmit the same for approval.

3.2 The fabrication drawings shall indicate complete details of fabrication and erection including all erection splicing details and typical fabrication splicing details, lacing details, weld sizes and lengths. Bolt details and all customary details in accordance with standard structural engineering practice. The fabrication drawing and bill of material based on design/line diagram shall be submitted to NEA for approval. Approved bill of materials prepared on the basis of fabrication drawing shall be the basis for payment.

3.3 Such approvals shall, however, not relieve the contractor of his responsibility for safety and durability of the structure and good connection and any loss occurring due to defective fabrication, design or workmanship shall be borne by the contractor.

3.4 The contractor shall submit editable soft copy of all designs preferably in Suitable structure analysis software/excel form and drawings in AutoCAD to NEA. The contractor shall submit the copy of relevant portion of British standard Codes (BS Codes)/ Indian Standard Codes (IS Codes)/equivalent International Standards referred to NEA for reference if necessary during detailed engineering stage.

4.0 FABRICATION AND ERECTION

4.1 The fabrication and erection works shall be carried out generally in accordance with relevant British standard Codes (BS Codes)/ Indian Standard Codes (IS Codes)/equivalent International Standards. All materials shall be completely shop fabricated and finished with proper connection material and erection marks for ready assembly in the field.

4.2 The component parts shall be assembled in such a manner that they are neither twisted nor otherwise damaged and shall be so prepared that the specified camber, if any, is provided. In order to minimize distortion in member the component parts shall be positioned by using the clamps, clips, dogs, jigs and other suitable means and fasteners (bolts and welds) shall be placed in a balanced pattern. If the individual components are to be bolted, paralleled and tapered drifts shall be used to align the part so that the bolts can be accurately positioned.

4.3 Sample towers, beams and lightning masts and equipment support structures may be trial assembled in the fabrication shop to ensure fitment of various members and to avoid problems during erection.

4.4 For all structures, BOM along with fabrication drawings in hard and editable soft copies shall be submitted to NEA as document for information. The responsibility of correctness of such fabrication drawing and BOM shall be fully with the contractor.

4.5 Approval of fabrication drawings and BOM shall, however, not relieve the Contractor of his responsibility for the safety and durability of the structure and good connections and any loss or damage occurring due to defective fabrication, design or workmanship shall be borne by the Contractor.

4.6 The Contractor should arrange on his own all plant and equipment, welding set, tools and tackles, scaffolding, trestles equipments and all other accessories and ancillaries required for carrying out erection without causing any stresses in the members which may cause deformation and permanent damage. Minor modification if any, required during erection shall be done at site with the approval of NEA.

5.0 BOLTING

i) Every bolt shall be provided with a washer under the nut so that no part of the threaded portion of the bolt is within the thickness of the parts bolted together.

ii) In case of fasteners, the galvanizing shall confirm to relevant British standard Codes (BS Codes)/ Indian Standard Codes (IS Codes)/equivalent International Standards. The spring washer shall be electro galvanized as per relevant British standard Codes (BS Codes)/ Indian Standard Codes (IS Codes)/equivalent International Standards.

6.0 WELDING

The work shall be done as per approved fabrication drawings which shall clearly indicate various details of joints to be welded, type of weld, length and size of weld, Symbols for welding on erection and shop drawings shall be according to relevant International Standards. Welding shall be carried out in accordance to relevant British standard Codes (BS Codes)/ Indian Standard Codes (IS Codes)/equivalent International Standards.

7.0 FOUNDATION BOLTS

7.1 Foundation bolts for the towers and equipment supporting structures and elsewhere shall be embedded in first stage concrete while the foundation is cast. The Contractor shall ensure the proper alignment of these bolts to match the holes in the base plate.

7.2 The Contractor shall be responsible for the correct alignment and leveling of all steel work on site to ensure that the towers/structures are plumb.

7.3 All foundation bolts for lattice structure, pipe structure are to be supplied by the Contractor.

7.4 All foundation bolts shall be fully galvanised so as to achieve minimum 610 grammes Per Sq.m. of Zinc Coating as per relevant British standard Codes (BS Codes)/ Indian Standard Codes (IS Codes)/equivalent International Standards.

7.5 All foundation bolts and its material shall conform to relevant British standard Codes (BS Codes)/ Indian Standard Codes (IS Codes)/equivalent International Standards. All foundation bolts shall be provided with two number standard nuts, one check nut, one plain washer and MS plate at the bottom of foundation bolt.

8.0 STABILITY OF STRUCTURE

The Supplier shall be responsible for the stability of the structure at all stages of its erection at site and shall take all necessary measures by the additions of temporary bracings and guying to ensure adequate resistance to wind and also to loads due to erection equipment and their operations.

9.0 GROUTING

The method of grouting the column bases shall be subject to approval of NEA and shall be such as to ensure a complete uniformity of contact over the whole area of the steel base. No additional payment for grouting shall be admissible.

10.0 GALVANISING

10.1 All structural steel works (Gantry structures, Equipment support structures) and foundation bolts shall be galvanized after fabrication. The galvanization shall be done as per requirement relevant British standard Codes (BS Codes)/ Indian Standard Codes(IS Codes)/equivalent International Standards.

10.2 Zinc required for galvanizing shall have to be arranged by the Contractor/manufacturer. Purity of zinc to be used shall be 99.95% as per relevant British standard Codes (BS Codes)/ Indian Standard Codes (IS Codes)/equivalent International Standards.

10.3 The Contractor shall be required to make arrangement for frequent inspection by the owner as well as continuous inspection by a resident representative of the owner, if so desired for fabrication work.

11.0 TOUCH-UP PAINTING

Minor defects in hot dip galvanized members shall be repaired by applying zinc rich primer and two coats of enamel paint to the satisfaction of NEA before erection.

12.0 DISPATCH INSPECTION BEFORE

Each part of the fabricated steel work shall be inspected as per approved quality plans and certified by NEA or his authorized representative as satisfactory before it is dispatched to the erection site. Such certification shall not relieve the Contractor of his responsibility regarding adequacy and completeness of fabrication.

13.0 TEST CERTIFICATE

Copies of all test certificates relating to material procured by the Contractor for the works shall be submitted to NEA.

14.0 MODE OF MEASUREMENT

The measurement of the structure, fasteners (Nuts, Bolts, and Washers) and foundation bolts including its nuts washers and MS Plate at bottom shall be done as per Bid price schedule (Schedules of Rates and Prices). The weight of all structural members and foundation bolts (Bolt, Nuts, washer and MS steel plates welded at bottom of bolt) shall be measured under one head in Metric Tonne. The weight of fasteners and step bolts (Nuts, bolts and washers) used to erect/complete structures shall be measured under another head in Metric tons.

15.0 SAFETY PRECAUTIONS

The Contractor shall strictly follow all precautions at all stages of fabrication, transportation and erection of steel structures. The stipulations contained in relevant British standard Codes (BS Codes)/ Indian Standard Codes (IS Codes)/equivalent International Standards for Safety during erection of structural steel work shall also be adhered to.

16.0 MANUFACTURING QUALITY PLAN

The material specification shall also be as per British standard Codes (BS Codes)/ Indian Standard Codes (IS Codes)/equivalent International Standards.

The Contractor shall prepare the manufacturing quality plan to accept/check the material, galvanization and welding as per relevant international standards/BS codes within 1 month after award of work and submit the same to NEA for approval.

CHAPTER 16: CIVIL WORKS

1.0 GENERAL

The intent of specification covers the following:

Design, engineering, drawing and construction of all civil works at sub-station. All civil works shall also satisfy the general technical requirements specified in other Sections of Specification and as detailed below. They shall be designed to the required service conditions/loads as specified elsewhere in this Specification or implied as per relevant British standard codes (B S Codes)/Indian Standard Code (IS Code)/ equivalent International Standards.

All civil works shall be carried out as per applicable Standards and Codes. All materials shall be of best quality conforming to relevant International Standards and Codes. In case of any conflict between Standards/ Code and Technical Specification, the provisions of Technical Specification shall prevail.

The Contractor shall furnish all design, drawings, labour, tools, equipment, materials, temporary works, constructional plant and machinery, fuel supply, transportation and all other incidental items not shown or specified but as may be required for complete performance of the Works in accordance with approved drawings, specifications and direction of NEA.

The work shall be carried out according to the design/drawings to be developed by the Contractor and approved by the NEA. For all buildings, structures, foundations etc. necessary layout and details shall be developed by the Contractor keeping in view the functional requirement of the substation facilities and providing enough space and access for operation, use and maintenance. Certain minimum requirements are indicated in this specification for guidance purposes only. However, the Contractor shall quote according to the complete requirements.

2.0 GEOTECHNICAL INVESTIGATION

2.1 The Contractor shall perform a detailed soil investigation to arrive at sufficiently accurate, general as well as specific information about the soil profile and the necessary soil parameters of the Site in order that the foundation of the various structures can be designed and constructed safely and rationally.

A detailed soil report including field data will be submitted by the Contractor for specific approval of Owner**.** The report shall contain all soil parameters along with recommendation of soil consultant for type of foundation i.e. pile or open type, soil treatment if any etc to be used for the design of civil foundations.

2.2 The Contractor may visit the site to ascertain the soil parameters. Any variation in soil data shall not constitute a valid reason for any additional cost & shall not affect the terms & conditions of the contract. Field tests must be conducted covering entire substation area including all the critical locations i.e. GIS Building, Control building, Lightning Mast. Tower locations, transformer/Reactor etc.

2.3 **SCOPE OF WORK**

This specification covers all the work required for detailed soil investigation and preparation of a detailed report. The work shall include mobilisation of necessary equipment, providing necessary engineering supervision and technical personnel, skilled and unskilled labour etc. as required to carry out field investigation as well as, laboratory investigation, analysis and interpretation of data and results, preparation of detailed Geo-technical report including specific recommendations for the type of foundations and the allowable safe bearing capacity for different sizes of foundations at different founding strata for the various structures of the substation. The Contractor shall make his own arrangement for locating the co-ordinates and various test positions in field as per the information supplied to him and also for determining the reduced level of these locations with respect to the benchmark indicated by the Owner. The soil investigation for 220 kV switch yard extension in existing switch yard has not been envisaged. Soil data of 400 kV yard under the present scope shall be referred for the design of foundations in switch yard extension.

All the work shall be carried out as per latest edition of the corresponding relevant British standard codes (B S Codes)/Indian Standard Code (IS Code)/ equivalent International Standards.

2.3.1 **Bore Holes**

Bore holes of Minimum 150 mm diameter in accordance with the provisions of relevant international standards/British standards(BS)/IS at the rate of minimum one number bore hole per hectare up to 15meter depth(Minimum) or to refusal which ever occur earlier shall be drilled for new areas (400 kV Yards wherever applicable). In any case number of boreholes shall not be less than four. By refusal it shall mean that a standard penetration blow count (N) of 100 is recorded for 30 cm penetration. Number of boreholes may be increased in case soil strata is varying from borehole to borehole in order to have fair idea of soil profile. In case of deep pile foundations soil investigation is to be carried out up to 25 m depth from ground level or refusal whichever is earlier. In case rock is encountered, coring in all the boreholes shall be carried out up to 3 meter in rock.

Performing Standard Penetration Tests at approximately 1.5 m interval in the borehole starting from 0.5 m below ground level onwards and at every change of stratum. The disturbed samples from the standard penetrometer shall also be collected for necessary tests. Standard Penetration Test shall be performed as per relevant British standard codes (B S Codes)/Indian Standard Code (IS Code)/ equivalent International Standards.

Undisturbed samples shall be collected in accordance with the recommendation of relevant British standard codes (B S Codes)/Indian Standard Code (IS Code)/ equivalent International Standards. Or an alternative recognize method as agreed by Owner. Undisturbed samples shall be taken in cohesive material or weak cemented granular material where ever possible at 1.0 m interval or at each change in stratum.

The depth of Water Table, if encountered, shall be recorded in each borehole. In case the soil investigation is carried out in winter/summer, the water table for rainy season shall be collected from reliable sources and recorded in the report.

All samples, both disturbed and undisturbed, shall be identified properly with the borehole number and depth from which they have been taken.

The sample shall be sealed at both ends of the sampling tubes with wax immediately after the sampling and shall be packed properly and transported to the Contractor's laboratory without any damage or loss.

The logging of the boreholes shall be compiled immediately after the boring is completed and a copy of the bore log shall be handed over to the Engineer-in-change.

2.3.2 Trial Pits

The Contractor shall excavate two number trial pits per substation as and where directed by Owner, of Plan area 10 sq.m and not exceeding 4 m depth. Undisturbed samples shall be taken from the trial pits as per the direction of the Owner. All Trial Pits shall be re-filled with approved material after the tests are complete and shall be well compacted in layers of not exceeding 300 mm in thickness in loose stage measurement.

2.3.3 Electrical Resistivity Test

This test shall be conducted to determine the Electrical resistivity of soil required for designing safety-grounding system for the entire station area. The specifications for the equipments and other accessories required for performing electrical resistivity test, the test procedure, and reporting of field observations shall confirm to relevant British standard codes (B S Codes)/Indian Standard Code (IS Code)/ equivalent International Standards. The test shall be conducted using Wagner's four electrode method as specified in relevant British standard codes (B S Codes)/Indian Standard Code (IS Code)/ equivalent International Standards. Unless otherwise specified at each test location, the test shall be conducted along two perpendicular lines parallel to the coordinate axis. On each line a minimum of 8 to 10 readings shall be taken by changing the spacing of the electrodes from an initial small value of 0.2 m upto a distance of 50.0 m.

2.3.4 **Plate load test**

Plate load test shall be conducted at the location of GIS building, Control building and transformer area as applicable only to determine the bearing capacity, modulus of sub grade reaction and load/settlement characteristics of soil at shallow depths by loading a plane and level steel plate kept at the desired depth and measuring the settlement under different loads, until a desired settlement takes place or failure occurs. The specification for the equipment and accessories required for conducting the test, the test procedure, field observations and reporting of results shall conform to relevant BS standards/IS standards/equivalent international standards. Plate load test shall be performed at the proposed foundation depth below finished ground level for bearing capacity.

Undisturbed tube samples shall also be collected from the pit at 1.0 m depth and bottom of pit from natural ground level for carrying out laboratory tests.

The size of the pit in plate load test shall not be less than five times the plate size and shall be taken up to the specified depth. All provisions regarding excavation and visual examination of pit shall apply here.

Unless otherwise specified the reaction method of loading shall be adopted. Settlement shall be recorded from dial gauges placed at four diametrically opposite ends of the test plate.

The load shall be increased in stages. Under each loading stage, record of Time vs Settlement shall be kept as specified in relevant British standard codes (BS Codes)/Indian Standard Code (IS Code)/ equivalent International Standards.

Backfilling of the pit shall be carried out as per the directions of the Owner**.** Unless otherwise specified the excavated soil shall be used for this purpose. In cases of gravel-boulder or rocky strata, respective relevant codes shall be followed for tests.

2.3.5 **Water Sample**

Representative samples of ground water shall be taken when ground water is first encountered before the addition of water to aid drilling of boreholes. The samples shall be of sufficient quantity for chemical analysis to be carried out and shall be stored in air-tight containers.

2.3.6 **Back Filling of Bore Holes**

On completion of each hole, the Contractor shall backfill all bore holes as directed by the Owner. The backfill material can be the excavated material.

2.3.7 **Laboratory Test**

2.3.7.1. The laboratory tests shall be carried out progressively during the field work after sufficient number of samples have reached the laboratory in order that the test results of the initial bore holes can be made use of in planning the later stages of the field investigation and quantum of laboratory tests.

2.3.7.2. All samples brought from field, whether disturbed or undisturbed shall be extracted/prepared and examined by competent technical personnel, and the test shall be carried out as per the procedures laid out in the relevant British standard codes (B S Codes)/Indian Standard Code (IS Code)/ equivalent International Standards.

The following laboratory tests shall be carried out

a) Visual and Engineering Classification

b) Atterberg limits Tests.

c) Natural moisture content, bulk density and specific gravity.

d) Grain size distribution analysis.

e) Swell pressure and free swell index determination.

f) California bearing ratio.

g) Consolidated drained test with pore pressure measurement.

h) Chemical tests on soil and water to determine the carbonates, sulphates, nitrates, chlorides, Ph value, and organic matter and any other chemical harmful to the concrete foundation.

i) In case rock is encountered, the soil test required for rock as per relevant British standard codes (B S Codes)/Indian standard code (IS code)/equivalent International Standards including following tests shall also be conducted.
   (i) UCC test.
   (ii) Point load index test.

2.3.8 Test Results and Reports

The Contractor shall submit the detailed report in two (2) copies wherein information regarding the geological detail of the site, summarised observations and test data, bore logs, and conclusions and recommendations on the type of foundations with supporting calculations for the recommendations. The contractor shall also submit the bearing capacity calculation in editable soft copy to Owner. Initially the contractor shall submit draft report and after the draft report is approved, the final report in two (2) copies shall be submitted. The field and laboratory test data shall bear the signatures of the Investigation Agency, Contractor and also site representative of Owner.

The report shall include, but not limited to the following:-

a) A plan showing the locations of the exploration work i.e. bore holes, trial pits. Plate load test, electrical resistivity test, CBR sample location etc.

b) Bore Logs: Bore logs of each bore holes clearly identifying the stratification and the type of soil stratum with depth. The values of Standard Penetration Test (SPT) at the depths where the tests were conducted on the samples collected at various depths shall be clearly shown against that particular stratum.

   Test results of field and laboratory tests shall be summarised strata wise as well in combined tabular form. All relevant graphs, charts tables, diagrams and photographs, if any, shall be submitted along with report. Sample illustrative reference calculations for settlement, bearing capacity, pile capacity shall be enclosed.

Recommendations: The report should contain specific recommendations for the type of foundation for the various structures envisaged at site. The Contractor shall acquaint himself about the type of structures and their functions from the Owner. The observations and recommendations shall include but not limited to the following:

a) Geological formation of the area, past observations or historical data, if available, for the area and for the structures in the nearby area, fluctuations of water table etc.

b) Recommended type of foundations for various structures. If piles are recommended the type, size and capacity of pile and groups of piles shall be given after comparing different types and sizes of piles and pile groups.

c) Allowable bearing pressure on the soil at various depths for different sizes of the foundations based on shear strength and settlement characteristics of soil with supporting calculations. Minimum factor of safety for calculating net safe bearing capacity shall be taken as 3.0 (three). Recommendation of liquefaction characteristics of soil if applicable shall be provided.

d) Recommendations regarding slope of excavations and dewatering schemes, if required.

e) Comments on the Chemical nature of soil and ground water with due regard to deleterious effects of the same on concrete and steel and recommendations for protective measures.

f) If expansive soil is met with, recommendations on removal or retainment of the same under the structure, road, drains, etc. and thickness of treatment shall be given. In the latter case detailed specification of any special treatment required including specification or materials to be used, construction method, equipments to be deployed etc. shall be furnished. Illustrative diagram of a symbolic foundation showing details shall be furnished.

a) Recommendations for additional investigations beyond the scope of the present work, if considered such investigation as necessary.

f) In case of foundation in rocky strata, type of foundation and recommendation regarding rock anchoring etc. should also be given.

3.0 SITE CLEARING, CONTOUR SURVEY AND SITE LEVELLING

3.1 **SITE CLEARING**:

The work shall consist of numbering of trees, removing and disposing of all materials such as trees, bushes, woods, shrubs, grass, stumps, rubbish, rank vegetation, roots, foreign materials,150mm of top soil etc., which in the opinion of the Engineer-in-Charge are unsuitable for incorporation in the works, from within the limits and areas as may be specified by the Engineer-in-Charge.

All trees shall also be cut and useful portion of the trees so cut shall be stacked at a suitable place as directed by the Engineer-in-Charge and shall be considered incidental to clearing and grubbing operations.

The roots of trees shall be dug up to 60 cm below the ground level or 15 cm below formation level whichever is deeper and after removal of all vegetable and organic matter from the holes so formed by removal of the roots, holes and hollows shall be filled with good earth in layer of 20 cm, well rammed, consolidated and levelled.

The serviceable and unserviceable materials obtained from the site clearance shall be removed from the area and disposed of to a place as per the directions of the Engineer-in-Charge.

Clearing and grubbing item is not payable and the same shall be deemed to be included in the earth work in site levelling.

3.2 **CONTOUR SURVEY & SITE LEVELLING**:

The land for construction of substation will be handed over to the successful bidder as on where basis progressively after award of work. The contractor shall carry out survey work by taking spot level with respect to temporary bench mark transferred from permanent bench mark in the locality if available either on bride/railway platform or government buildings of local authorities. The contractor shall submit the spot levels in editable soft copy in excel format and contour map with contour interval of 0.25 m in editable auto cad soft drawing.

The contractor will level the area required for construction of substation work either at single level, multi-level or gradual slope with the finished ground level as approved by Owner during detailed engineering based on highest flood level. The levelling area shall be decided by Owner during detailed Engineering stage.

The layout and levels of all structure etc. shall be made by the Contractor at his own cost from the plot and benchmarks set by the Contractor and approved by Owner. The Contractor shall provide all assistance in instruments, materials and personnel to Owner for checking the detailed layout and shall be solely responsible for the correctness of the layout and levels.

3.3 SCOPE

This clause covers clearance of site, contour survey, site levelling, maintaining finished ground level by cutting/filling, supplying and compaction of fill material if required. Cutting/felling of trees and their disposal has not been envisaged under the present scope.

3.4 GENERAL

Site shall be cleared, surveyed and levelled/sloped by the contractor as per approved general arrangement drawing or levelling area decided during detailed engineering after award of work.

Work covered under this clause comprises the site clearance, survey work/setting out and making profiles, Earth work in Excavation & filling in specified area with all lifts and leads and earth work in filling with borrowed earth with all leads and lifts (Borrow areas including payment of royalty for borrowed earth shall be arranged by the contractor at his own cost). During detailed engineering stage, the contractor will prepare the levelling proposal for optimum levelling and submit to Owner for approval. The earthwork is calculated by making cross-section of contour plan at 5m interval along longitudinal and transverse direction separately, final quantity of earthwork is the average of quantity at longitudinal and transvers direction. Contractor shall submit the hard copy and editable soft copy of levelling proposal (levelling quantity calculation in Excel form and levelling drawing in Auto CAD) to Owner for approval.

Filling material shall conform to relevant British standard codes (BS Codes)/ IS/ equivalent International Standards. Unsuitable filling material if any shall be removed and replaced by suitable fill material. The filling shall be compacted in layers to achieve 95% of standard Proctor's density at Optimum moisture contents (OMC). Cohesion less material shall be compacted to 70% relative density (minimum). Levelling/Filling shall be carried out as per relevant British standard codes (B S Codes)/IS/ equivalent International Standards.

3.3 SLOPE PROTECTION WORK IN FILLING AREA

This clause covers slope protection work in filling area if height of filling is very high. Requirement of slope protection work is decided by Employer.

A) Grouted Stone Pitching:

It covers the furnishing of materials and construction of a protective covering in stone pitching on exposed surfaces such as earth slopes .The area shall be prepared by excavating, shaping and trimming to accommodate the stone work and shall be thoroughly compacted. A trench shall be excavated as directed by the Engineer along the toe of any slope to be pitched or along the unprotected edge of the pitching in the bed of streams. The spaces between the stones shall be filled with 1:3 cement sand mortar. Before the mortar is applied the surfaces of the stones shall be thoroughly cleaned of adhering dust and vegetation and then moistened.

The mortar shall be placed in a continuous operation for any day's run at any one location. The mortar shall be worked in to the pitching so as to ensure that all spaces or voids between the stones are completely filled with mortar and to the depth of stone pitching.

After the grout has been placed, the stones shall be thoroughly brushed so that their top surfaces are exposed. The grouted pitching shall be cured for a period of not less than four days after grouting with wet sacking or other approved wet cover, and shall not be subjected to loading until adequate strength has been developed. Where required, or instructed by the Engineer, weep holes shall be formed in the pitching.

Materials

Stone: Stone for pitching shall be sound, tough and durable, with no stone less than 100mm in minimum dimension, except that smaller pieces or spalls may be used for filling spaces between the larger stones. Stone shall be of such a shape as to form a stable protection structure of the required section. All stone intended for use on any particular pitching job shall receive the prior approval of the Engineer.

Mortar: Mortar for all stonework shall consist of cement and clean, sharp, coarse sand. The mortar shall consist of one part cement and 3 parts sand used in pitching stone masonry work.

Water: Water used for mixing mortar shall be in accordance with of NBC 110-2050.

B) BIO ENGINEERING WORK(GRASS PLANTATION ON SLOPED SURFACE)

1.SITE PLANTING AND SOWING:

General

The Contractor shall plant or sow grasses as required by the Engineer. This shall be done according to the specifications described hereunder, as and when required. The Contractor shall supply all necessary expertise, resources and facilities to ensure that these requirements are met.

It is the Contractor’s responsibility to ensure that all planting stock, whether provided from a nursery or through a separate instruction, is of high quality and is vigorous enough to grow on the site to be planted.

All seeds and other planting stock must be of species indigenous to Nepal unless otherwise specified. All species must be covered in the current approved lists of species produced from time to time by the Geo-Environmental. They must be appropriate for the precise site conditions in which they are to be planted and the Contractor must ensure that they apply to the specific altitude and other environmental characteristics of the site in question.

The timing of many bio-engineering operations is of the utmost importance. Activities such as planting and seed sowing must be carried out within the critical few weeks when they will yield the desired results. All other operations must be carried out in a timely manner to permit this to happen. The Contractor is responsible to keep works to the strict schedule required and under no circumstances to permit delays.

2 SOWING OF GRASSES ON SITE:

The sowing of grasses is intended to create a strengthened slope surface which is resistant to erosion. The Contractor is required to carry out the sowing of grass seeds according to the Employer's representative's specific instructions.

It is assumed that the site will already have been prepared for seed sowing, under a separate instruction; but it is nevertheless the responsibility of the Contractor to ensure that the condition of the site is good enough for the successful establishment of grasses.

The Contractor is required to supervise all field operations very closely. The sowing of grass seeds is a delicate business and should be approached in the same way as for agricultural crops. The Contractor should employ experienced agricultural labourers for this work.

Seeds will have been collected and stored under a separate instruction well before the time of sowing. However, it is the Contractor’s responsibility to check that it has been carefully stored and remains fully viable.

Immediately before sowing, the ground surface should be lightly scarified to ease early root penetration. Seeds should then be laid thinly over the surface. Under no circumstances should they be broadcast, because the lightness of perennial grass seeds and the steepness of the slopes to be treated give a poor cover using such a technique. The Contractor responsible for ensuring that the correct quantities of seeds are used, while giving a good, even cover.

A cover of 25 grams of grass seed per square meter of surface should be achieved unless otherwise specified.

After sowing, a mulch of prepared and dried cut herbs should be laid over the whole seeded area in a thin layer. If the mulch is too thick it will prevent light from getting to the seed and will inhibit germination. Herbs suitable for this and locally available in large quantities are:

- tite pate (Artemisia vulgans);
- tapre (Cassia species);
- banmara (Eupatorium adenophorum).

However, freshly cut herbs should not be used because of the danger of resprouting and weeding.

If specified, the mulch should be secured with jute netting of mesh size 300 x 500 mm and the netting fixed in place using suitable live pegs or hardwood cuttings (e.g. simali, Vitexnegundo) at one meter centers.

3 COMPOST AND MULCH PRODUCTION

The Contractor is to produce compost and mulch for nursery or site operations. It is to be produced in a timely manner, in the quantities required. Compost is normally required to sustain the long term fertility of nursery beds. Mulch may also be used in the nursery, but is normally produced to enhance site planting works, particularly the direct seeding of grass.

Compost and mulch should be made from annual and perennial weeds of poor rooting characteristics, such as ban mara (Eupatorium adenopherum) and tite pate (Artemesiavulgans). The greenery should be collected when there is most material available but before it forms seeds.

Collected material should be chopped finely and stored in a mound, compost bay or pit. The maximum size for chopped compost is 50 mm; the maximum size for chopped mulch is 150 mm.

Both compost and mulch should be kept moist but not waterlogged and in an aerated condition. They should be completely turned once a month on a regular schedule. Compost can have cow manure mixed in to assist the process of decomposition.

Neither compost nor mulch should be applied until they are fully rotted. By this time they should be black and the parts of individual plants should be indistinguishable. Early application can lead to a nutrient loss in the soil if microbes extract nitrogen to decompose the added organic material.

4 SITE PROTECTION/ SITE AFTERCARE AND MAINTENANCE

The Contractor is to protect a planted site for the period specified. Protection is to include the prevention of damage to all manner of site works and plants by local people and domestic or wild animals. It also includes an active role in tending the plants and improving their growth. The period of maintenance by the Contractor will be for six months

The Contractor shall maintain planted bio-engineering sites as required by the Engineer. This shall be done according to the specifications described hereunder, as and when required. The Contractor shall supply all necessary expertise and resources to ensure that these requirements are met.

The Contractor shall carry out weeding as required throughout the site. All annual weeds and other unwanted plants shall be cut just above the ground and the aerial parts will be used to make compost or mulch. Weeds must not be pulled out by the roots since this disturbs the ground surface.

Weeding should be carried out throughout the growing season. It must be undertaken with particular diligence at the end of the monsoon, so that there is the minimum amount of competition during the subsequent dry season.

The Contractor shall carry out mulching as required throughout the site. All plants required under the bio-engineering specifications will be mulched using material prepared as specified in above, or the aerial parts of weeds cut on the site or brought from elsewhere for the purpose. The desired plants should be kept mulched at all times but especial care must be taken in the spring, when the soil moisture deficit is at its greatest.

The Contractor shall replace failed, damaged, diseased and very weak plants, using fresh, healthy plants of the same species, at the correct time of year for planting. This replanting operation will normally be carried out during the monsoon in the year following the first planting works. Vegetation structures will be enriched by the planting of additional cuttings or seedlings, as instructed by the Engineer. Failed seeding areas will be re-seeded at the appropriate time of year.

In replanting and enrichment works, the Engineer may specify the use of different species. This will be done where failures of poor performance of plants may be attributed to poor stock or an incorrect initial choice of species.

Other maintenance operations are to be undertaken by the Contractor according to the instructions of the Engineer.

4.0 SITE PREPERATION, EXCAVATION, BACKFILL & DISPOSAL OF SURPLUS EARTH.

4.1 SITE PREPERATION

The layout and levels of all structure etc shall be made by the Contractor at his own cost from the general grids of the plot and benchmarks set by the Contractor and approved by the Owner. The Contractor shall give all help in instruments, materials and personnel to the Owner for checking the detailed layout and shall be solely responsible for the correctness of the layout and levels.

4.2 **SCOPE**

This clause covers clearing of the site, maintaining the finished ground level with available surplus excavated suitable back fill material generated from foundation works etc.

4.3 **GENERAL**

i. The Contractor shall develop the site area to meet the requirement of the intended purpose. The site preparation shall conform to the requirements of relevant sections of this specification or as per stipulations of relevant British standard codes (B S Codes)/ IS/ equivalent International Standards.

ii. The fill material shall be suitable for the above requirement. The fill shall be with such a material that the site so designed shall not be affected by erosion from wind and water from its final compacted position or the in-situ position of undisturbed soil.

iii. Material unsuitable for founding of foundations shall be removed and replaced by suitable fill material to be approved by the Owner.

iv. Backfill material around foundations or other works shall be suitable for the purpose for which it is used and compacted to the density described under Compaction. Excavated material not suitable or not required for backfill shall be disposed off in areas as directed by employer up to a maximum lead of 2 km.

4.4 **EXCAVATION AND BACKFILL**

SCOPE

This clause covers excavation for foundation works of Towers, Equipment support structures, Transformer/Reactor foundations, External Lighting poles, Cable trenches, Buildings, Fire Wall, Water tanks, etc, backfilling of Foundations Works.

a. Excavation and backfill for foundations shall be in accordance with the relevant British standard codes (B S Codes)/ IS code/equivalent International Standards.

b. Whenever water table is met during the excavation, it shall be dewatered and water table shall be maintained below the bottom of the excavation level during excavation, concreting and backfilling.

c. When embankments are to be constructed on slopes of 15% or greater, benches or steps with horizontal and vertical faces shall be cut in the original slope prior to placement of embankment material. Vertical faces shall measure not more than 1 m in height.

d. Embankments adjacent to abutments, culverts, retaining walls and similar structures shall be constructed by compacting the material in successive uniform horizontal layers not exceeding 15 cm in thickness. (of loose material before compaction). Each layer shall be compacted as required by means of mechanical tampers approved by the Purchaser. Rocks larger than 10 cm in any direction shall not be placed in embankment adjacent to structures.

e. Earth embankments of roadways and site areas adjacent to buildings shall be placed in successive uniform horizontal layers not exceeding 20 cm in thickness in loose stage measurement and compacted to the full width specified. The upper surface of the embankment shall be shaped so as to provide complete drainage of surface water at all times.

f. Do not disturb material below the bottom of footing grade. Do not backfill to compensate for excavation that has extended below grade. If excavation occurs below the proposed footing grade, fill the area with M15 concrete at the time the footing is placed. The additional concrete placed will be at the Contractor's expense.

4.5 COMPACTION

a. The density to which fill materials shall be compacted shall be as per relevant BS/IS and as per direction of Owner. All compacted sand filling shall be confined as far as practicable. Backfilled earth shall be compacted to minimum 95% of the Standard Proctor's density at OMC. The sub grade for the roads and embankment filling shall be compacted to minimum 95% of the Standard Proctor's density at OMC. Cohesion less material sub grade shall be compacted to 70% relative density (minimum).

b. At all times unfinished construction shall have adequate drainage upon completion of the road's surface course, adjacent shoulders shall be given a final shaping, true alignment and grade.

c. Each layer of earth embankment when compacted shall be as close to optimum moisture content as practicable. Embankment material which does not contain sufficient moisture to obtain proper compaction shall be wetted. If the material contains any excess moisture, then it shall be allowed to dry before rolling. The rolling shall begin at the edges overlapping half the width of the roller each time and progress to the centre of the road or towards the building as applicable. Rolling will also be required on rock fills. No compaction shall be carried out in rainy weather.

4.6 REQUIREMENT FOR FILL MATERIAL UNDER FOUNDATION

The thickness of fill material under the foundations shall be such that the maximum pressure from the footing, transferred through the fill material and distributed onto the original undisturbed soil will not exceed the allowable soil bearing pressure of the original undisturbed soil. For expansive soils, the fill materials and other protections etc. to be used under the foundation is to be got approved by the Owner.

4.7 DISPOSAL OF SURPLUS EARTH

The surplus earth generated from foundation work shall be disposed away from levelling area boundary at low lying areas within 2Km lead. The surplus earth if disposed within substation main boundary, the same shall be spread in uniform layers and compacted with suitable compacting equipment to achieve 95% compaction at O.M.C.

5.0 ANTIWEED TREATMENT & STONE SPREADING

5.1 SCOPE OF WORK

The Contractor shall furnish all labour, equipment and materials required for complete performance of the work in accordance with the drawings, specification.

Stone spreading along with cement concrete layer shall be done in the areas of the switchyard under present scope of work within fenced area.

However the stone spreading along with cement concrete layer in future areas within fenced area shall also be provided in case step potential without stone layer is not well within safe limits.

5.2 GENERAL REQUIREMENT

The material required for site surfacing/stone filling shall be free from all types of organic materials and shall be of standard quality, and as approved by the Employer.
The material to be used for stone filling/site surfacing shall be stone aggregate of 40mm nominal size (ungraded single size) conforming to Table 2 of 15:383- 1970. Hardness, flakiness shall be as required for wearing courses are given below:

I. Sieve Analysis limits (Gradation) (IS : 383 - Table - 2)

Sieve size	% passing by weight
63mm	100
40mm	85-100
20mm	0-20
10mm	0-5

II. Hardness: Abrasion value (15:2386Part-IV) - not more than 40%
Impact value (IS:2386 Part-IV) - not more than 30%.

III. Flakiness Index: As per IS: 2386 Part -I maximum value is 25%.

After all the structures/equipments are erected, anti-weed treatment shall be applied in the switchyard where ever stone spreading along with cement concrete is to be done and the area shall be thoroughly de-weeded including removal of roots. The recommendation of local agriculture or horticulture department may be sought where ever feasible while choosing the type of chemical to be used. The anti-weed chemical shall be procured from reputed manufacturers. The doses and application of chemical shall be strictly done as per manufacturer's recommendation. Nevertheless the effectiveness of the chemical shall be demonstrated by the contractor in a test area of 10MX10M (appx.) and shall be sprinkled with water at least once in the afternoon every day after forty eight hours of application of chemical. The treated area shall be monitored over a period of two to three weeks for any growth of weeds by the Owner. The final approval shall be given by Owner based on the results.

Owner shall decide final formation level so as to ensure that the site appears uniform devoid of undulations. The final formation level shall however be very close to the formation level indicated in the approved drawing.

After anti weed treatment is complete, the surface of the switchyard area shall be maintained, rolled/compacted to the lines and grades as decided by Owner. The sub grade shall be consolidated by using half ton roller with suitable water sprinkling arrangement to form a smooth and compact surface. The roller shall run over the sub grade till the soil is evenly and densely consolidated and behaves as an elastic mass.

In areas that are considered by the Owner to be too congested with foundations and structures for proper rolling of the site surfacing material by normal rolling equipments, the material shall be compacted by hand, if necessary. Due care shall be exercised so as not to damage any foundation structures or equipment during rolling compaction.

The sub grade shall be in moist condition at the time the cement concrete is placed. If necessary, it should be saturated with water for not less than 6 hours but not exceeding 20 hours before placing of cement concrete. If it becomes dry prior to the actual placing of cement concrete, it shall be sprinkled with water and it shall be ensured that no pools of water or soft patches are formed on the surface.

Over the prepared sub grade, 75mm thick base layer of cement concrete in 1:5:10 (1 cement :5 sand : 10 Stone aggregates) shall be provided in the area excluding roads, drains, cable trenches as per detailed engineering drawing. For easy drainage of water, the slope of 1:1000 is to be provided from the ridge to the nearest drain. The ridge shall be suitably located at the centre of the area between the nearest drains. The above slope shall be provided at the top of base layer of cement concrete in 1:5:10. A layer of cement slurry of mix 1:6 (1 cement: 6 sand) shall be laid uniformly over cement concrete layer. The cement consumption for cement slurry shall not be less than 150 kg. Per 100 sq.m.

A final layer of 100mm thickness of uncrushed/crushed/broken stone of 40mm nominal size (ungraded size) shall be spread uniformly over cement concrete layer after curing is complete.

6.0 SITE DRAINAGE

Preparation of overall drainage layout, design, drawing and providing rain water drainage system within the switchyard fencing under the present scope including connection at one or more points to the outfall point located outside the substation boundary wall is in the scope of contractor. Invert level of drainage system at outfall point shall be decided in such a way that the water can easily be discharged outside the substation boundary wall. In case outfall point is more than 50M away from boundary wall, only 50 metre drain outside the boundary wall is in the scope of contractor. Outfall point shall be got approved from Owner before commencement of construction. While designing the drainage system following points shall taken care of:

(a) The surface of the switchyard shall be sloped to prevent accumulation of water.

(b) Drain shall be constructed at suitable locations in such a way that switchyard is not flooded and roads are not affected with ponding of surface water. In the switchyard maximum spacing between two drains shall not be more than 100 meter. It will be ensured that no area is left undrained.

(c) Open surface drains having minimum 300mm bottom width and 300mm depth at starting point of drain shall be provided. The depth of drain shall be measured with respect to finished ground level of switch yard i.e. from bottom of switch yard stone filling.

(d) Longitudinal slope shall not be less than 1 in 1000.

(e) Open surface drains shall be constructed with brick masonry.25 mm thick PCC (1:2:4) shall be laid over 75mm thick layer of PCC 1:4:8 (1 cement: 4coarse sand: 8 stone aggregate 20mm nominal size.)

(f) The side wall of the drains shall be 25 mm above the gravel level to prevent falling of gravel into drain. Groove of 125 mm width shall be provided at 2000 mm spacing with suitable mild steel grating..

(g) The maximum velocity for pipe drains and open drains shall be limited to 2.4m/sec and 1.8m/sec respectively. However, minimum non-silting velocity of 0.6m/sec shall be ensured.

(h) Pipe drains shall be provided in areas of switchyard where movement of crane will be necessary in operating phase of the substation.

(i) For pipe drains, road crossings etc. higher strength pipe of class NP3 shall be provided. For rail crossings, RCC pipes of class NP4 shall be provided. For design of RCC pipes for drains and culverts, relevant British standard codes (B S Codes)/IS code/ equivalent International Standards shall be followed.

(j) Suitable number of portable pumps of 5 hp capacity for drainage of water shall be provided by the Contractor.

(k) Pipe drains shall be connected through manholes at an interval of max. 30m.

(l) If the invert level of outfall point is above the last drain point in the substation boundary, sump of suitable size has to be constructed with in the substation boundary.

(m) The drainage scheme and associated drawings shall be got approved from Owner before commencement of construction.

7.0 ROADS

a). All the roads as shown in the General Arrangement drawing for the substation issued along with the tender documents are in the present scope. Adequate turning space for vehicles shall be provided and bend radii shall be set accordingly. Road to the Transformer /Reactor shall be as short and straight as possible.

b) All concrete roads within substation boundary wall shall be with 3.75 m RCC concrete pavement of suitable thickness and 1.3 m wide earthen shoulder on either side of the road. Below RCC concrete pavement, water bound macadam of adequate thickness as per design (WBM) shall be laid.

e) All roads shall be designed as per relevant British standard codes (B S Codes)/IS/ equivalent International Standards. All drawings of road and culverts shall be prepared by the contractor and shall got approved from Employer before commencement of construction.

f) All the culverts and allied structures (required for road/rail, drain, trench crossings etc.) shall be designed as per relevant British standard codes (B S Codes)/IS/ equivalent International Standards.

8.0 TRANSFORMERS/REACTOR FOUNDATION, RAIL TRACK/ RAIL CUM ROAD TRACK

The Contractor shall design, prepare drawing and provide a RCC Rail cum road system integrated with the Transformer/Reactor foundation to enable installation and the replacement of any failed unit. The transfer track system shall be suitable to permit the movement of any failed unit fully assembled (including OLTC, bushings) with oil. This system shall enable the removal of any failed unit from its foundation to the nearest road. If trench/drain crossings are required then suitable R.C.C. culverts shall be provided in accordance with relevant BS/IS/ equivalent International Standards.

The Contractor shall provide a pylon support system for supporting the fire fighting system.

Each Transformer /Reactor including oil conservator tank and cooler banks etc. shall be placed in a self-sufficient pit surrounded by retaining walls (Pit walls). The clear distance of the retaining wall of the pit from the Transformer/Reactor shall be 20% of the Transformer /Reactor height or 0.8m whichever is more. The oil collection pit thus formed shall have a void volume equal to 200% volume for 400 kV and 130% for 220 kV of total oil in the Transformer /Reactor. The minimum height of the retaining walls shall be 15 cm above the finished level of the ground to avoid outside water pouring inside the pit. The bottom of the pit shall have an uniform slope towards the sump pit. While designing the oil collection pit, the movement of the Transformer must be taken into account.

The grating shall be made of MS flat of size 40mmx 5mm placed at 30mm center to center and 25mmx5mm MS flat at spacing of 150mm at right angle to each other. Maximum length of grating shall be 2000mm and width shall not be more than 500mm. The gratings, supported on ISMB 150mm, shall be placed at the formation level and will be covered with 100mm thick layer of broken/crushed/non-crushed stone having size 40mm to 60mm which acts as an extinguisher for flaming oil. All steel works used for grating and support in transformer foundation shall be painted with Zinc phosphate primer (two packs) conforming to relevant British standard codes (B S Codes)/IS/equivalent International Standards.

Each oil collection pit shall be drained towards a sump pit within the collection pit whose role is to drain water and oil due to leakage within the collection pit so that collection pit remains dry.

8.1 MATERIALS

Complete foundation shall be made of reinforced cement concrete and shall be designed as per guidelines for design of foundations given in clause 11.0 in the specification.

8.2 DRAINAGE

One 0.5 H.P pump for each pit shall be supplied and installed by the Contractor to evacuate the fire fighting & rain water from the sump pit in to the nearest drain.

9.0 FIRE PROTECTION WALLS

9.1 GENERAL

Fire protection walls shall be provided, if required, in accordance with Local Advisory Committee (LAC) recommendations. The scope of works covers design, preparation of drawing and construction of RCC fire protection walls. While designing the wall, following points may be taken care of:

9.1.1 FIRE RESISTANCE

The firewall shall have a minimum fire resistance of 3 hours. The partitions, which are made to reduce the noise level, shall have the same fire resistance. The walls of the building, which are used as firewalls, shall also have a minimum fire resistance of 3 hours.

The firewall shall be designed to protect against the effect of radiant heat and flying debris from an adjacent fire.

9.1.2 DIMENSIONS

The firewall shall extend 600 mm on each side of the Transformer /Reactors and 600 mm above the conservator tank or safety vent.

These dimensions might be reduced in special cases, as per the approval of owner where there is lack of space. A minimum of 2.0meter clearance shall be provided between the equipments e.g. Transformer /Reactors and firewalls.

The building walls, which act as firewalls, shall extend at least 1 m above the roof in order to protect it.

9.1.3 MATERIALS

The firewall will be made of reinforced cement concrete as per the relevant British standard codes (B S Codes)/ IS/equivalent International Standards.

10.0 CABLE TRENCHES AND CABLE TRENCH CROSSINGS

The work covered under this clause comprises of design, drawing and construction cable trenches and cable trench crossings. While designing, following points may be taken care of:

a) The cable trenches and pre-cast removable RCC cover (with lifting arrangement) shall be constructed using RCC of M25 (Minimum) grade as per relevant British standard codes (B S Codes)/IS code/ equivalent International Standards.

b) The cable trench walls shall be designed for the following loads.

(i) Dead load of 155 kg/m length of cable support + 75 Kg on one tier at the outer edge of tier.
(ii) Earth pressure + uniform surcharge pressure of 2T/m2.

c) Cable trench covers shall be designed for self-weight of top slab + concentrated load of 150 kg at centre of span on each panel.

d) Necessary sumps shall be provided and each sump shall be provided with pumps of 5 HP capacity shall be supplied for pumping out water collected in cable trench. Cable trenches shall not be used as storm water drains.

e) The top of trenches shall be kept at least 100 mm above the finished ground level. The top of cable trench shall be such that the surface rainwater do not enter the trench.

f). All metal parts inside the trench shall be connected to the earthing system.

g) Trench wall shall not foul with the foundation. Suitable clear gap shall be provided.

h) The trench bed shall have a slope of 1/500 along the run & 1/250 perpendicular to the run.

i) Cable trenches shall be blocked at the ends if required with brick masonry in cement sand mortar 1:6 and plaster with 12mm thick 1:6 cement sand mortar.

J) Cable trench crossings shall be designed for critical load likely to be passed over the crossing. The cable trench crossing may be of either RCC box culvert type or RCC hume pipes embedded in plain concrete as per design of contractor.

11.0 FOUNDATION / RCC CONSTRUCTION

11.1 GENERAL

11.1.1 Work covered under this Clause of the Specification comprises the design ,drawing and construction of foundations and other RCC constructions for switchyard tower structures, bus supports, equipment supports, cable trenches, Transformer /Reactors, jacking pad, pulling blocks, fire protection walls, control cubicles, marshalling kiosks, auxiliary equipments, GIS building, Control Building, Diesel Generator(DG) building or for any other equipment or service and any other foundation required to complete the work. This clause is as well applicable to the other RCC constructions.

11.1.2. Concrete shall conform to the requirements mentioned in relevant British standard codes (B S Codes)/IS/ equivalent International Standards and all the tests shall be conducted as per relevant British standard codes (B S Codes)/ IS/ equivalent International Standards. However, a minimum grade of M25 (design Mix) concrete shall be used for all foundations and structural/load bearing members as per relevant British standard codes (B S Codes)/IS/ equivalent International Standards.

11.1.3. If the site is sloppy, the foundation height will be adjusted to maintain the exact level of the top of structures to compensate such slopes.

11.1.4. The switchyard foundation's plinths and building plinths shall be minimum 300mm and 500 mm above finished ground level respectively.

11.1.5. Minimum 75mm thick lean concrete (1:4:8) shall be provided below all underground structures, foundations, trenches etc. to provide a base for construction.

11.1.6. The design and detailing of foundations shall be done based on the approved soil data and sub-soil conditions as well as for all possible critical loads and the combinations thereof. The Spread footings foundation or pile foundation as may be required based on soil/sub-soil conditions and superimposed loads shall be provided.

11.2 DESIGN

While designing foundations, following may be taken care of:

11.2.1. All foundations except for external lighting poles shall be of reinforced cement concrete. The external lighting pole shall be embedded in plain cement concrete (1:2:4) foundation. The design and construction of RCC structures shall be carried out as per relevant BS/IS and minimum grade of concrete shall be M-25 (design Mix). Higher grade of concrete than specified above may be used at the discretion of Contractor without any additional financial implication to the Owner.

11.2.2. Limit state method or any other method as per relevant British standard codes (B S Codes)/IS/ equivalent International Standards of design shall be adopted unless otherwise specified in the specification.

11.2.3. For detailing of reinforcement relevant BS/IS/equivalent International Standards followed. Cold twisted deformed bars conforming to relevant British standard codes (B S Codes)/IS/equivalent International Standards. Two layers of reinforcement (on inner and outer face) shall be provided for wall & slab sections having thickness of 150 mm and above. Clear cover to reinforcement shall be as per relevant British standard codes (B S Codes)/ IS/equivalent International Standards.

11.2.4. RCC water retaining structures like storage tanks, etc. shall be designed as uncracked section in accordance with relevant British standard codes (B S Codes)/IS code/equivalent International Standards. However, water channels shall be designed as cracked section with limited steel stresses as per relevant BS/IS.

11.2.5. The procedure used for the design of the foundations shall be the most critical loading combination of the steel structure and or equipment and/or superstructure and other conditions which produces the maximum stresses in the foundation or the foundation component and as per the relevant British standard codes (B S Codes)/IS/equivalent International Standards of foundation design. Detailed design calculations shall be submitted by the bidder showing complete details.

11.2.6. Design shall consider any sub-soil water pressure that may be encountered following relevant standard strictly.

11.2.7. Necessary protection to the foundation work, if required shall be provided to take care of any special requirements for aggressive alkaline soil, black cotton soil or any other type of soil which is detrimental/harmful to the concrete foundations.

11.2.8. RCC columns shall be provided with rigid connection at the base.

11.2.9. All sub-structures shall be checked for sliding and overturning stability during both construction and operating conditions for various combinations of loads. Factors of safety for these cases shall be taken as mentioned in relevant British standard codes (B S Codes)/IS/ equivalent International Standards or as stipulated elsewhere in the Specifications. For checking against overturning, weight of soil vertically above footing shall be taken and inverted frustum of pyramid of earth on the foundation should not be considered.

11.2.10. Earth pressure for all underground structures shall be calculated using co-efficient of earth pressure at rest, co-efficient of active or passive earth pressure (whichever is applicable). However, for the design of substructures of any underground enclosures, earth pressure at rest shall be considered.

11.2.11. In addition to earth pressure and ground water pressure etc., a surcharge load of 2T/Sq.m shall also be considered for the design of all underground structures including channels, sumps, tanks, trenches, substructure of any underground hollow enclosure etc., for the vehicular traffic in the vicinity of the structure.

11.2.12. Following conditions shall be considered for the design of water tank in pumps house, channels, sumps, trenches and other underground structures:

a) Full water pressure from inside and no earth pressure & ground water pressure & surcharge pressure from outside (application only to structures which are liable to be filled up with water or any other liquid).

b) Full earth pressure, surcharge pressure and ground water pressure from outside and no water pressure from inside.

c) Design shall also be checked against buoyancy due to the ground water during construction and maintenance stages. Minimum factor of safety of 1.5 against buoyancy shall be ensured ignoring the superimposed loadings.

11.2.13. Base slab of any underground enclosure shall also be designed for empty condition during construction and maintenance stages with maximum ground water table (GWT). Minimum factor of safety of 1.5 against buoyancy shall be ensured ignoring the super-imposed loadings.

11.2.14. The foundations shall be proportioned so that the estimated total and differential movements of the foundations are not greater than the movements that the structure or equipment is designed to accommodate.

11.2.15. The foundations of transformer/reactor and circuit breaker shall be of lock type foundation. Minimum reinforcement shall be governed by relevant British standard codes (B S Codes)/ IS code/equivalent International Standards.

11.2.16. The tower and equipment foundations shall be checked for a factor of safety as per relevant British standard codes (B S Codes)/IS/equivalent International Standards for two conditions i.e. Normal condition and short circuit condition against sliding, overturning and pulloxcvut. The same factors shall be used as partial safety factor over loads in limit state design also.

11.3 ADMIXTURES & ADDITIVES

11.3.1. Only approved admixtures shall be used in the concrete for the Works. When more than one admixture is to be used, each admixture shall be batched in its own batch and added to the mixing water separately before discharging into the mixer. Admixtures shall be delivered in suitably labelled containers to enable identification.

11.3.2. Admixtures in concrete shall conform to relevant British standard codes (B S Codes)/IS/ equivalent International Standards. The water proofing cement additives shall conform to relevant BS/IS. Concrete Admixtures/ Additives shall be approved by Owner.

11.3.3. The Contractor may propose and the Owner may approve the use of a water-reducing set-retarding admixture in some of the concrete. The use of such an admixture will not be approved to overcome problems associated with inadequate concrete plant capacity or improperly planned placing operations and shall only be approved as an aid to overcoming unusual circumstances and placing conditions.

11.3.4. The water-reducing setting-retarding admixture shall be an approved brand as per relevant British standard codes (B S Codes)/IS/equivalent International Standards.

11.3.5 The water proofing cement additives shall be used as required/advised by Owner.

12.0 CHAINLINK FENCING AND GATE

12.1 General

Work covered under this clause comprises of design, drawing, supply, fabrication, erection, painting or galvanisation as specified etc of switch yard Fencing and gate, construction of foundation of steel posts and toe wall .While providing switch yard fencing and gate, following points may be taken care of:

12.2 Areas requiring Fencing

12.2.1 Fencing shall be provided for complete switchyard. Separate gate shall be provided for men and equipment.

12.2.2 Internal fence surrounding the various equipments if mounted on ground or a height lower than 2.5m. Necessary gates shall be provided for each area so surrounded.

12.3 Product materials

The minimum requirements are as follows:

Chain link fence fabric (galvanization) in accordance to relevant British standard codes (B S Codes)/ IS/ equivalent International Standards.

12.4 Posts

The posts shall be of medium M.S. tubes of 50mm diameter conforming to grade as per relevant international /BS standard. The tubes shall also conform relevant British standard codes (B S Codes)/IS code/ equivalent International Standards. The length of tubular post shall be 2600 mm.

An M.S. base plate of size 160 X 160 X 6mm thick shall be welded with the tubular post. The post shall be provided on the top with M S plate.

The tubular post shall be welded with 8 number of M S flat of size 50 x 6mm – 75mm long at suitable locations. Two number of 13.5 mm diameter holes on each cleats shall be provided to bolt the fence fabric panel. The cleats shall be welded at equal spacing in such a way that 4 numbers of cleats are on one side and remaining 4 cleats are on the opposite side of the post. The cleats on the corner posts shall be welded in such a way that it suits the site requirement.

The whole assembly of tubular post shall be hot dip galvanized. The zinc coating shall be minimum 610 gram per sq. meter. The purity of zinc shall be 99.95% as per relevant BS/IS/Equivalent International standards.

12.5 Fence Fabric & Fence Panel

Chain link fencing shall be made of 3.15 mm diameter wire with 75 X 75 mm mesh size. Fence fabric shall be galvanised. Chain link fencing shall be fabricated in the form of panel as per requirement An M.S. flat of at least 50x6 mm size shall be welded all-round fence fabric to form a panel. Four pairs of 13.5mm diameter holes on the vertical M S flat matching the spacing of holes in cleats fixed with pipe shall be provided to fix the fence panel with the tubular posts. A washer shall also be provided below each nut. The contractor, for fixing the panels, shall supply the 12mm diameter bolts including nuts and washers. All nuts, bolts and washers shall be hot dip galvanized.

The fence panel shall be provided with two or more coats of approved standard Zinc paint over approved standard steel primer.

12.6 Installation

12.6.1. Fence shall be installed along the switchyard line.
12.6.2. Post holes shall be excavated by approved method.
12.6.3. All posts shall be 3.0m apart measured parallel to ground surface.
12.6.4. Posts shall be set in 1:2:4 Plain Cement Concrete block of minimum

0.40x0.40x1.2m depth. 75mm thick plain cement concrete 1:4:8 shall be provided below concrete blocks. Posts shall be braced and held in plumb position and true alignment and elevation until concrete has set.

12.6.5. Fence fabric shall not be installed until concrete has cured a minimum of 7 days.

12.6.6. Fence fabric panel shall be fixed to the post at 4 nos. MS flat each of 50x6, 75 long through 2 nos. of bolts (12mm diameter) on each flat.

12.7 **Gate**

12.7.1. The gate shall be made of medium duty M.S. pipe conforming to relevant I.S. with welded joints. The main frame (outer frame) of the gate shall be made of 40mm dia pipe and vertical pipes of 15mm dia. @ 125mm spacing (maximum) shall be welded with the main frame. Two number of 1.25 mm thick and 125 mm wide MS plates (Horizontal) @ 500 mm centre to centre distance shall be welded on each gate leaf. Gate leaves shall be fixed with a vertical post of 2700 mm long two steel channels-150 welded together. An 8 mm thick 200X 200 mm size MS plate shall be welded at the bottom of channel frame.

12.7.2. The gates shall be fabricated with welded joints to achieve rigid connections. The gate frames shall be painted with one coat of approved steel primer and two coats of synthetic enamel paint.

12.7.3. The gates shall be provided with suitable locking arrangement welded on 4 mm thick MS plate on the gate leaf.

12.7.4. The main gate shall be 5.0m wide and shall be of double leaf type. Next to the main gate, a men gate (1.25m wide single leaf) shall also be provided.

12.7.5. Steel roller shall be provided with the gate.

12.7.6. Gate shall be installed in location as shown in approved G.A. drawing.

12.7.7. The vertical post of gate shall be embedded in PCC foundation of 500 X500X1250 mm deep size.

13. Buildings - GENERAL REQUIREMENTS

13.1 GENERAL

The scope include the design, engineering and construction including anti-termite treatment, Plinth protection, DPC, Peripheral drain, Sanitary, Water supply, Electrification etc. of GIS building, two story RCC control building and Diesel Generator (DG) enclosure.

The contractor shall appoint a reputed architect for design of architecturally pleasing building.

13.2 AREA REQUIREMENT:-

Dimensions of the building shall be decided by the bidder depending upon requirement. Provision for extension in future of the building shall be made in GIS Hall. A corridor having minimum width of 1500 mm shall be provided all around GIS Hall to facilitate maintenance of equipments. Pre- engineered steel structure GIS building consist of GIS hall, Room for control, protection & communication panels and AHU room. Provision for service bay shall also be made. GIS building shall also include a store room of suitable size for storing all the spares to be supplied as detailed in annexure-I of Chapter 1-PSR. The size and layout of the store room shall be finalized by the bidder so as to ensure proper storage of all spares in line with the storage instructions of respective manufacturers. The finish schedule of the store room shall be same as that of GIS hall.

Dimension for two story RCC control building is decided by contractor but having minimum dimension as per drawing attached with tender document. Finishing schedules and door window schedules are given in table 1 below.

Separate enclosure building for Diesel Generator (DG) shall be provided as per Chapter-DG set.

The GIS building shall be of pre-engineered steel structure. Internal access to the GIS hall from control room building (if applicable) shall be provided.

Material specification and other details for construction of Pre-engineered steel building shall be as described in subsequent paragraphs. The base plate of steel columns shall be mounted on the RCC foundation by means of foundation bolts.

In order to facilitate inspection and maintenance, the structures shall be provided with climbing devices. The built up frame shall be applied with a priming coat of red oxide zinc chromate primmer before taken out of workshop. Separate fire escape doors shall also be provided in the GIS Building. Panels shall be kept in an air-conditioned enclosure preferably within the GIS hall. This enclosure shall be separated from main GIS hall by providing a glazed partition made of aluminium frame and 5.5mm thick glass.

Walkway of width not less than 1.0m shall be provided at gantry girder level on the two longer side of GIS hall along with climbing arrangement to facilitate maintenance of crane. All steel work shall be painted with one coat of steel primer and two coats of synthetic enamel paint after erection.

All the material required for Pre-engineered (steel) building shall be from reputed manufacturer for which prior approval shall be obtained from Owner. Manufacturing of various parts of the building shall start only after approval of "Manufacturing Quality Plan". Complete material shall be offered for inspection by owner before dispatch. Inspection shall be carried out based on assembly (fabrication) drawings approved by Employer and "BILL OF MATERIAL" & Shop drawing prepared by the Manufacturer and certified by the Contractor for its correctness. Approval of BOM and shop drawing from employer is not required.

13.3 DESIGN

a) The buildings shall be designed:

i. To the requirements of the International standards/British Standards/ Indian Standards.
ii. for the specified climatic & loading conditions.
iii. to adequately suit the requirements of the equipment and apparatus contained in the buildings and in all respects to be compatible with the intended use and occupancy.
iv. with a functional and economical space arrangement.
v. For a life expectancy of structure, systems and components not less than that of the equipment which is contained in the building, provided regular maintenance is carried out.
vi. to be aesthetically pleasing. Different buildings shall show a uniformity and consistency in architectural design.
vii. to allow for easy access to equipment and maintenance of the equipment.
viii. with, wherever required, fire retarding materials for walls, ceilings and doors, which would prevent supporting or spreading of fire.
ix. With materials preventing dust accumulation.
x. All structures shall be designed for the worst combination of dead loads, live loads, wind loads as per IS-875, seismic forces as per IS-1893.
xi. The design of steel structures for the GIS building shall be done in accordance with IS: 800.
xii. The design of R.C.C. structures for the GIS building, Control Building and DG building shall be done in accordance with IS: 456.
xiii. Permissible stresses for different load combinations shall be taken as per relevant IS Codes.

b) Suitable expansion joints shall be provided in the longitudinal direction wherever necessary with provision of twin columns.

c) Individual members of the buildings frame shall be designed for the worst combination of forces such as bending moment, axial force, shear force, torsion etc.

d) Permissible stresses for different load combinations shall be taken as per relevant IS Codes/BS code.

e) The building lighting shall be designed in accordance with the requirements of relevant section.

f) The building auxiliary services like air conditioning and ventilation systems, fire protection and detection systems and all other miscellaneous services shall be designed in accordance with the requirements specified in relevant section or elsewhere in this Specification.

g) Chequred plate walkway shall be provided at crane girder level with suitable access ladders.

13.4 DESIGN LOADS

Building structures shall be designed for the most critical combinations of dead loads, super- imposed loads, equipment loads, crane load (if any), wind loads and seismic loads.

Dead loads shall include the weight of structures complete with finishes, fixtures and partitions and should be taken as per IS:1911/BS/international standard.

Super-imposed loads in different areas shall include live loads, minor equipment loads, cable trays, small pipe racks/hangers and erection, operation and maintenance loads wherever these loads are expected. Equipment loads shall constitute, if applicable, all load of equipments to be supported on the building frame.

For crane loads an impact factor of 30% and lateral crane surge of 10% (lifted weight + trolley) shall be considered in the analysis of frame according to provisions of IS:875/BS/international standard. The horizontal surge shall be 5% of the static wheel load.

The wind loads shall be computed as per IS 875 - 1987/BS/international standard, Seismic Coefficient method/Response Spectrum method shall be used for the seismic analysis as per IS 1893 with importance factor 1.5.

Wind and Seismic forces shall not be considered to act simultaneously.

Floors/slabs shall be designed to carry loads imposed by equipment, cables and other loads associated with building. Floors shall be designed for live loads as per relevant IS/BS/international standard. Cable load shall also be considered additionally for floors where these loads are expected.

In addition, beams shall be designed for any incidental point loads to be applied at any point along the beams. The floor loads shall be subject to Owner's approval.

For consideration of loads on structures, IS:875/BS/international standard, the following minimum superimposed live loads shall, however, be considered for the design.

a.	Roof		1.5 KN/M^2	for accessible roofs
			0.75 KN/M^2	for in-accessible roofs
b.	RCC-Floor	(i)	5 KN/M^2	for offices
		(ii)	10 $KN/M^{2(min.)}$	For equipment floors or

			actual requirement, if higher than 10 kN/sqm based on equipment component weight and layout plans.
c.	Stairs & balconies	5 KN/M^2	
d.	Toilet Rooms	2 KN/M^2	
e.	Chequered plate floor	4 KN/M^2	
f.	Walkways	3 KN/M^2	

Any additional load coming in the structure shall be calculated as per IS: 875//BS/international standard.

13.5 SUBMISSION

The following information shall be submitted for review and approval to the Owner:

i. Soft as well as hard copies of structural design calculations and drawing (including construction/fabrication) for all reinforced concrete and structural steel structures.

ii. Fully, dimensioned concept plan including floor plans, cross sections, longitudinal sections, elevations and perspective view of each building. These drawings shall be drawn at a scale not smaller than 1:50 and shall identify the major building components.

iii. Fully dimensioned drawings showing details and sections drawn to scales of sufficient size to clearly show sizes and configuration of the building components and the relationship between them.

iv. Product information of building components and materials, including walls partitions flooring ceiling, roofing, door and windows and building finishes.

v. A detailed schedule of building finishes including colour schemes.

vi. A door & window schedule showing door types and locations, door lock sets and latch sets and other door hardware.

Approval of the above information shall be obtained before ordering

13.6 Material Specification PEB GIS Hall

i. Primary members fabricated from plates and sections with minimum yield strength of 345 Mpa or to suit design by continuous welding.

ii. Secondary members for Purlins and Grits shall conform to the physical specification of ASTM A570 (Grade 50) or equivalent IS/BS/ international Standards having a minimum yield strength of 345 MPa. The minimum thickness of secondary members shall be 2.5mm.

iii. Rod / ANGLE/pipe bracing shall conform to the physical specification of relevant BS/IS/equivalent international standards of minimum 245Mpa Yield Strength

iv. All hot rolled sections shall conform to the physical specifications of BS/IS/equivalent international standards. All other miscellaneous secondary members shall have minimum yield strength of 250 MPa.

13.6.1 DESCRIPTION

13.6.1.1 PRIMARY MEMBERS:

Primary structural framing shall include the transverse rigid frames, columns, corner columns, end wall wind columns and crane gantry girders and Frames at Door openings.

13.6.1.2 SECONDARY MEMBERS:

Secondary structural framing shall include the purlins, girts, eave struts, wind bracing, flange bracing, base angles, clips, flashings and other miscellaneous structural parts. Suitable wind bracings sag rods to be reckoned while designing the structure.

13.6.1.3 PURLINS:

Purlins should be of Pre Galvanised steel of 345 Mpa having a coating thickness of 275 gsm.

13.6.1.4. ROOF SHEETING

Factory assembled 50mm thick puff (density 40kg/cu.m. +2 Kg/cu m as per BS/equivalent International Standards) sandwiched panels shall be provided. These panels shall be made of puff insulation sandwiched between two high tensile steel sheets each of 0.5 mm thickness. The material of sheets shall confirm to ASTM 792 M Grade 345 with minimum yield strength of 345 Mpa. The steel sheets shall be provided with hot dip coating of Zinc aluminium alloy (approximately 55% Al, 43.5% Zn and 1.5 % silicon) .Total mass of zinc aluminium alloy coating shall be minimum 200 gm/Sq. m inclusive of both sides. The tolerance of base metal thickness (BMT) of steel sheet shall be as per BS/IS/equivalent International Standards. After hot dip coating of Zinc aluminium alloy, the sheet shall be provided with steel primer and silicon modified polyester (SMP) paint. The total thickness of primer and paint shall be 40 microns inclusive of both sides (TCT) comprising of 20 microns of SMP paint on top surface and 10 microns of backer coat (polyester coat) on back surface over 5 microns thick primer each on both surfaces with inorganic pigments coated free from heavy metals. Painting shall conform to BS/equivalent International Standards. In case SMP paint is not available, Super Durable Polyester paint (SDP) can also be used by the bidder without cost implication to Employer.

13.6.1.5 Wall Panels

Wall panel material specifications shall be same as roof panels.

13.6.1.6 SHEETING FASTENERS:

Standard fasteners shall be self-tapping zinc plated metal screws with EPDM bonded zinc plated washers. All screws shall be colour coated to match roof and wall sheeting.

13.6.1.7 SEALER:

This is to be applied at all side laps and end laps of roof panels and around self flashing windows. Sealer shall be pressure sensitive elastomeric Butyl tapes. The sealer shall be non-asphaltic, nonshrinking and non toxic and shall be superior adhesive metals, plastics and painted at temperatures from 51°C to + 104°C.

13.6.1.8 CLOSURES:

Solid or closed cell closures matching the profiles of the panel shall be installed along the eaves, rake and other locations specified on drawings.

13.6.1.9 FLASHING AND TRIM:

Flashing and / or trim shall be furnished at the rake, corners, eaves, and framed openings and wherever necessary to provide weather tightness and finished appearance. Colour shall be matching with the colour of wall. Material shall be 26 gauge thick conforming to the physical specifications of sheeting.

13.6.1.10 SKY LIGHTS:

Skylight is translucent corrugated sheets matching the profile of Roof. The translucent sheets are made from 2mm thick Polycarbonate sheets and shall provide an economic form of general-purpose day lighting. Skylights shall be provided for 5% of the roof area. Colour of the panel shall be white with smooth surface finish with a light **transmitting capacity of 60% ± 5%.**

13.6.1.11 GUTTERS AND DOWN SPOUTS:

Gutters and downspouts shall be adequately designed to ensure proper roof drainage system. Material shall be same as that of sheeting.

13.6.2 CONNECTIONS:

13.6.2.1 SITE CONNECTIONS

a) All primary bolted connections shall be provided with galvanized high strength bolts, washers, nuts conforming to specifications of relevant standard.

a) All secondary bolted connections shall be furnished with bolts, nuts, washers conforming to the specifications of grade 4.6 of relevant standard or ASTM-A307.

13.6.2.2 SHOP CONNECTIONS

All shop connections shall be welded with appropriate arc welding process and welding shall be in accordance with relevant international standard as appropriate. The Webs should be welded on to the flanges at both the faces at top and bottom for columns, beams and crane girders. Weld material should have strength more than the parent metal.

13.6.2.3 ROOF & WALL BRACINGS

Roof and wall bracings shall have minimum yield strength of 250 Mpa and shall conform to the specifications of relevant standard.

13.7 FLOORING

Flooring in various rooms of GIS hall, Control building and DG building shall be as per detailed schedule given in Table -1.

13.8 WALLS

In GIS building 230mm thick brick wall shall be provided up to first floor level of control building. 50mm thick puff sandwiched panels as described above shall be provided above brick wall. For control building and DG building all brick wall shall be 230 mm. Mortar used for brick wall shall be of 1:4 (1 cement and 4 sand)

13.9 ROOF

Roofing Panel for GIS hall: 50mm thick puff (density 40kg/cu.m.) sandwiched panels shall be provided as described in previous clauses. RCC roofing shall be provided for control building and DG building.

13.10 PLASTERING

All internal walls shall have minimum 15mm thick 1:4 cement sand plaster. The ceiling shall have 6mm thick 1:3 cement sand plaster.

13.11 EXTERNAL FINISHING

External plaster 18mm thick shall be of 1:4 cement sand plaster in two layers. External surface of the GIS building, control building and DG building shall be painted with exterior paint Weather Shield Max or Excel Total All as per manufacturer's specification.

13.12 INTERNAL FINISH SCHEDULE

The finishing schedule is given in subsequent clauses and table-1. Areas not specified in finish schedule shall be provided with vitrified tile flooring, and Premium Acrylic emulsion paint oil bound washable distemper over two mm thick putty. Paints used in the work shall be of best quality. Internal finish Schedule for GIS hall, two story RCC building and Diesel Generator (DG) building are given in Table - 1 below:

INTERNAL FINISH SCHEDULE (Table -1)

S.No.	LOCATION	FLOORING & SKIRTING 150MM HIGH	WALL (INTERNAL)	CEILING	DOOR, WINDOWS & VENTILATOR
1.	Control Room	Vitrified tiles 8mm thick size 600x600 mm	Non VOC acrylic emulsion paint over 2 mm POP putty upto false ceiling over approved primer coat	False ceiling painted with Non VOC acrylic emulsion paint to give an even shade	Windows/ ventilator shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be flush door shutters with powder coated aluminium frame.
2.	Conference Room	Vitrified tiles 8mm thick size 600 x 600mm	Non VOC acrylic emulsion paint over 2 mm POP putty upto false ceiling over approved primer coat	False ceiling painted with Non VOC acrylic emulsion paint to give an even shade	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
3.	(S/S In-charge Room)	Vitrified tiles 8mm thick size 600 x 600mm	Non VOC acrylic emulsion paint over 2 mm POP putty upto false ceiling over approved primer coat	False ceiling painted with Non VOC acrylic emulsion paint to give an even shade	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
4.	Other Office Room	Vitrified tiles 8mm thick size 600 x	Non VOC acrylic	False ceiling painted with	Windows shall be of powder coated

		600mm	emulsion paint over 2 mm POP putty upto false ceiling over approved primer coat	Non VOC acrylic emulsion paint to give an even shade	aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
5.	ACDC &DCDB Room	62 mm cement concrete flooring with hardener	Non VOC acrylic emulsion paint over 2 mm POP putty upto false ceiling over approved primer coat	False ceiling painted with Non VOC acrylic emulsion paint to give an even shade	Windows/ ventilator shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be flush door shutters with powder coated aluminium frame.
6.	Panel/Relay Room	Vitrified tiles 8mm thick size 600 x 600mm	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	False ceiling and White wash above False Ceiling	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
7.	AHU Room	62mm thick cement concrete flooring with metallic hardener topping	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	Acrylic emulsion paint over a coat of cement primer on smooth surface applied with readymade putty 2 mm thick	Windows/ ventilator shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be flush door shutters with powder coated aluminium frame.
8.	Battery Room	Acid resistant non-skid tiles on flooring and upto 2100mm height on wall.	Acid alkali resistant painting above 2100 mm height.	False ceiling and White wash above False Ceiling	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder

					coated aluminium doors with 5.5.mm thk. Glazing.
9	Lobby	18 mm thick granite flooring	Non VOC acrylic emulsion paint over 2 mm POP putty upto false ceiling over approved primer coat	False ceiling painted with Non VOC acrylic emulsion paint to give an even shade	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
10	Corridor	Vitrified tiles 8mm thick size 600 x 600mm	Non VOC acrylic emulsion paint over 2 mm POP putty upto false ceiling over approved primer coat	False ceiling painted with Non VOC acrylic emulsion paint to give an even shade	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
11	Portico for RCC Building	18 mm thick granite flooring	Granite cladding	Non VOC acrylic emulsion paint over approved primer coat	All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
12	Toilet	Ceramic Tiles	DADO glazed tiles 2100mm high, above that non VOC acrylic emulsion paint over 2 mm thick POP putty along with primer coat.	Non VOC acrylic emulsion paint over approved primer coat	All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
13	GIS HALL	62 mm thick cement concrete flooring with hardener. Two coat of PU coating	Non VOC acrylic emulsion paint over 2 mm POP putty	In case of RCC roof, ceiling shall be finished with non VOC	Windows/ ventilator shall be of powder coated aluminium with 5.5mm thick

		over the floor shall be provided. The final coat of PU shall be applied after the installation of equipments. Total thickness of PU coats shall be minimum of 300 microns.	upto false ceiling over approved primer coat over plastered surface.	acrylic emulsion painted over approved primer coat.	glazing. All doors shall be flush door shutters. (35 mm thick block board with commercial veneer on the both side with lipping with powder coated aluminium frame.)
14	Diesel Generator (DG) room	Ceramic Tiles	DADO glazed tiles 2100mm high, above that non VOC acrylic emulsion paint over 2 mm thick POP putty along with primer coat.	Non VOC acrylic emulsion paint over approved primer coat	Windows/ ventilator shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be flush door shutters made of pre-laminated particle board.
15	RCC Staircase	18 mm thick Granite slab on riser and treads	Non VOC acrylic emulsion paint over 2 mm POP putty upto false ceiling over approved primer coat	False ceiling painted with Non VOC acrylic emulsion paint to give an even shade	Windows/ ventilator shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be flush door shutters with powder coated aluminium frame.

13.13 CABLE TRENCH IN GIS HALL AND CONTROL BUILDING

All cable trenches in GIS hall and Control Building shall be covered with minimum 6mm thick MS chequered plate with suitable stiffeners.

13.14 DOORS AND WINDOWS

The details of doors and windows of the buildings shall be as per finish schedule Table-1 conforming to relevant IS code. Rolling steel shutters and rolling steel grills shall be provided as per layout and requirement of buildings. Main entrance door to GIS building shall be made of powder coated aluminium frame with 5.5 mm thick glazing.

13.15 PARTITION ON GIS HALL

Partitions, if required, shall be made of powder coated aluminium frame provided with 5.5 mm thick clear glass or pre- laminated board depending upon the location of partition.

13.16 PLUMBING & SANITATION

a. All plumbing and sanitation works shall be executed to comply with the requirements of the appropriate bye-laws, rules and regulations of the Local Authority having jurisdiction over such matters. The Contractor shall arrange for all necessary formalities to be met with regards to the inspection, testing, obtaining approval and giving notices etc.
b. 'SINTEX' or an equivalent make PVC Roof water tank(s) with metal stand of adequate capacity depending on the number of users for 24 hours storage shall be provided. However, a minimum of 2 nos. 1500 liter capacity shall be provided.
c. Chlorinated Polyvinyl chloride (CPVC) pipes having thermal stability for hot and cold water supply including all CPVC plain and brass threading conforming to relevant British standard codes (B S Codes)/IS/equivalent International Standards shall be used for internal piping works for water supply.
d. For internal soil, waste and vent pipe Unplasticised rigid PVC pipes of 75mm for waste & 110mm dia for soil shall be provided conforming to 15:13592 type B and all its fittings like bends, sockets, door bend, Y-tee etc. as per requirement with seal ring conforming to IS: 5382 including jointing with cement solvent conforms to 15:14182.All underground or under floor pipes shall be encased with 1:4:8 concrete. Minimum concrete cover shall be 75 mm thick.
e. There shall be separate provision of toilet for Male and Female and In addition to general requirements of each toilets, 2 nos. urinals with flushing system shall be provided for common Male toilet.
f. Each toilet shall have the following minimum fittings:
g. WC (Western type) 390 mm high along with toilet paper roll holder and all other fittings in all toilets.
h. Urinal (430 x 260 x 350 mm size) with all fittings and built-in-sensor for

automatic flush after use.

i. Wash basin (550 x 400 mm) with all fittings.

j. Bathroom mirror (600 x 450 x 6 mm thick) with hard board backing.

i. CP brass towel rail (600 x 20 mm) with CP brass brackets.

ii. Soap holder and liquid soap dispenser.

iii. Automatic Hand Dryer.

iv. Water cooler for drinking water with adequate water storage facility shall be provided which shall preferably be located near pantry and away from the toilet block.

v. One no. stainless steel kitchen sink with Drain board (510 x 1040 x 178 mm bowl depth) for pantry shall be provided.

vi. All fittings, fasteners, gratings shall be chromium plated.

vii. All sanitary fixtures and fittings shall be of approved quality and type, manufactured by reputed manufacturers. All items brought to site must bear identification marks of the Manufacturer.

viii. Contractor shall provide necessary nos. of septic tank and soak pit of adequate capacity to treat the sewage/sullage from the buildings.

ix. Contractor shall undertake all other activities required to complete and commission the building.

13.17 EXTERNAL PAINTING

External surfaces of the GIS Building shall be painted with acrylic exterior flat paint as per manufacturer's specification and approval of Owner.

13.18 DOORS, WINDOWS AND VENTILATORS

The schedule of doors, windows and ventilators of the GIS Building shall be as per the detailed finish schedule given in Table-1 (Detailed Finish Schedule), and shall conform to the relevant British standard codes (B S Codes)/IS/ equivalent International Standards. Rolling Steel shutters shall be provided as per the layout and requirements of the building. Main entrance door to GIS building shall be made of powder coated aluminium frame with 5.5 mm thick glazing.

13.19 PLINTH PROTECTION

750 mm wide plinth protection around the all buildings shall be provided. Plinth protection shall comprise of 50 mm thick plain cement concrete laid over 75 mm thick well compacted stone aggregates with interstices filled with local sand.

13.20 BUILDING STORM WATER DRAINAGE

a. The building design shall provide for the collection of storm water from the roof. This water shall be drained to the main drainage system of the Sub-station.
b. UPVC Rainwater down comer pipes conforming to relevant International standards/British Standards with water tight lead joints sconforms to relevant British standard codes (B S Codes)/IS code/ equivalent International Standards shall be provided to drain off the rain water from the roofs. These pipes shall be suitably concealed with masonry work or cement concrete or cladding material. The number and size of down comer pipes shall be governed by relevant British standard codes (B S Codes)/ IS code/equivalent International Standards.
c. All drains around the buildings shall have minimum 40 mm thick grating covers; and in areas where heavy equipment loads are envisaged, Pre-Cast RCC covers shall be provided in place of steel grating.
d. Suitable arrangements for draining out water collected from equipment blowdowns, leakages, floor washings, firefighting etc. shall be provided for each floor.

13.21 FALSE CEILING

Providing and fixing 15mm thick approximately 600 X 600mm Mineral fiber board panel false ceiling and making cut-outs for electrical fixtures, AC diffusers, openable access etc. complete with silhouette profile system with 15mm wide flange incorporating 6mm central recess white / black main runners at 1200mm centre-centre and not greater than 600mm from the adjacent wall. The cross tees shall be provided to make a module of approximately 600mm X 600mm by fitting 600 mm long cross tees centrally placed between 1200 mm long cross tees. Cross tees also have 15mm wide flange incorporating 6mm central recess white/black. The module formed above shall be anchored to the slab with channels or angles, suspenders as per manufacturer's specifications.

13.22 **Underdeck Insulation**

The method of fixing shall consist of slotted M.S. angles of appropriate size (minimum 65x50x2mm) fixed to soffit of RCC roof slab at 600mm centres in both directions by Rawl plugs of adequate strength. The slots shall have 14g G.I. tie wire drawn through them.

50mm thick insulation mat Fibreglass Crown - 100 or equivalent shall, be made out of fibre-glass or approved equivalent conforming to relevant international standard, backed with 34g aluminium foil and 22g x 12mm mesh wire netting. The net shall be stretched tightly across the slotted angles or slotted plates holding it in place by means of wires. The joints of the wire netting shall be butted and tightly laced down with 14g G.I. wire. The system shall be got approved from Owner.

13.23 **ELECTRIFICATION**

All electrification shall be executed as per details specified elsewhere in the technical specification. All details shall be as per relevant British standard codes (B S Codes)/ IS code/equivalent International Standards.

13.24 **Water Proofing Treatment For RCC Roof/Terrace**

Roof of the Building shall consist of Cast-in-situ RCC slab treated with a water proofing system which shall be an integral cement based treatment conforming to relevant British standard codes (B S Codes)/IS/equivalent International Standards. The water proofing treatment shall be of following operations:

(a) Applying and grouting a slurry coat of neat cement using 2.75 kg/m2 of cement admixed with proprietary water proofing compounds conforming to relevant British standard codes (B S Codes)/IS/equivalent International Standards over the RCC slab including cleaning the surface before treatment.
(b) Laying brick bats using broken brick/brick bats of 25mm to 100mm size with 50% of cement mortar 1:5 (1 cement: 5 coarse sand) admixed with proprietary water proofing compound conforming to relevant British standard codes (B S Codes)/ IS/equivalent International Standards over 20mm thick layer of cement mortar of min 1:5 (Cement: 5 coarse sand) admixed with proprietary water proofing compound conforming to relevant British standard codes (B S Codes)/IS/ equivalent International Standards to required slope and treating similarly the adjoining walls up to 300mm height including rounding of junctions of walls and slabs.

(c) After two days of proper curing applying a second coat of cement slurry admixed with proprietary water proofing compound conforming relevant British standard codes (B S Codes)/IS/ equivalent International Standards.

(d) Finishing the surface with 20mm thick joint less cement mortar of mix 1:4 (1 cement: 4 course sand) admixed with proprietary water proofing compound conforming to relevant British standard codes (B S Codes)/ equivalent International Standards and finally finishing the surface with trowel with neat cement slurry and making of 300 x 300 mm square.

(e) The whole terrace so finished shall be flooded with water for a minimum period of two weeks for curing and for final test. All above operations to be done in order and as directed and specified by the Engineer-in-charge.

(f) Average thickness of water proofing shall be 120 mm and minimum thickness at khurra shall be 65 mm.

14.0 WATER SUPPLY

14.1 GENERAL REQUIREMENTS

(i) Water shall be made available by Contractor at any feasible point within substation boundary by Bore well so that minimum pipe will be required for supply of water from that point to the buildings. The point for Bore Well shall got approved by employer. Contractor shall state the total water requirement both in terms of quantity and head to Owner.

(ii) The contractor shall carry out all the plumbing/erection works required for supply of water in GIS hall and control building beyond the single point as at (i) above. 50 mm dia CPVC pipe shall be provided by the Contractor from the bore-well to the roof water tank. From this contractor shall provide 25 mm dia CPVC pipe for internal water supply on building sand 12.5 mm dia CPVC pipe for branch connections.

(iii) The details of tanks, pipes, fittings, fixtures etc for water supply are given elsewhere in the specification under respective sections.

(iv) A scheme shall be prepared by the contractor indicating the layout and details of water supply which shall be got approved by Owner before actual start of work including all other incidental items not shown or specified but as may be required for complete performance of the works. All drawings shall be prepared by the contractor for approval of Owner.

14.2 DIGGING OF ONE NUMBER OF BORE WELL FOR WATER SUPPLY

I. Digging of 1 bore well of 150 mm diameter to a depth of 50 m with 3HP submersible pump set with sufficient head to deliver water upto roof top water tank, supply of required materials includes 80mm G.I delivery pipe and erection of pump set including accessories, testing and commissioning of pump sets.

II. Digging depth may be less than 50 m if quality and quantity of water available is satisfactory to higher depth.

III. Contractor shall supplying and installation of 3 HP 3 phase, multi stage 64 m (minimum) head pump suitable to 150 mm bore well with 80 mm GI pipe from pump delivery point to ground level .

IV. Bore well shall be fixed with of 150 mm dia class 3 PVC pipe partly slotted 1.5 mm below submersible pump and remaining portion upto ground level with covering the slotted portion by Nylon mesh firmly tied with Nylon/copper wire.

15.0 SEWERAGE SYSTEM

(i) Sewerage system shall be provided for GIS building and control building.

(ii) The Contractor shall construct septic tank and soak pit for required numbers of user but minimum of 50 users.If septic and soak pit system is not acceptable by local Nepal Authority, contractor will have to install suitable sewerage system as per local statutory requirement.

(iii) The system shall be designed as per relevant British standard codes (B S Codes)/ IS code/equivalent International Standards. All drawings shall be prepared by the contractor for approval of Owner.

16.0 MODE OF MEASUREMENT

16.1 Geotechnical investigation

This shall include carrying out field tests, laboratory tests, compilation of results and preparation of soil report with recommendations for type of foundations shallow or pile type, suitability of soil for construction of substation etc. The geotechnical investigation work shall be measured on lump sum basis.

16.2 **Site Clearing, Contour survey and site leveling.**

The site clearing work and contour survey work shall not be measured and paid separately and shall be deemed to be included in the item of site leveling work.
Measurement of Earth work in all kind of soil including rock in the item of cutting and filling and item of earth work in the filling with borrowed earth shall be made in Cubic meters.

16.3 **Earthwork**

This shall include excavation in all kinds of soil including rock, all leads and lifts including back filling with suitable earth, compacting, dewatering (if required) and disposal of surplus earth or rock to a suitable location within a lead up to 2 km. The surplus earth if disposed within substation boundary shall be spread in uniform layers each compacted with two passes of suitable compacting equipment. The quantity of excavation for foundations of towers, equipment support structures, all transformers/Reactors, firewall, cable trenches, buildings, External lighting poles, control cubicles, marshalling box shall only be measured. The quantity of excavation for roads, rail cum road, drains, culverts, rainwater harvesting, septic tank, soak pit, external water supply system, site surfacing, chain link fencing (including gate) shall not be measured separately and shall be deemed to be included in the composite rates quoted by the bidder for the respective works. All other excavation required for the completion of the work including plinth protection, flooring, sewerage system, manholes, pipes, earth mat etc. shall also not be paid for. The measurement of excavation of all concrete works shall be made considering dimension of the pit leaving 150mm gap around the base pad (lean concrete) or actually excavated pit, whichever is less. The quantity shall be measured in cubic meters.

16.4 **PCC**

Providing and laying Plain Cement Concrete of all types and at all locations including all leads and lifts. The quantity shall be measured in cubic meters as per lines and levels indicated in the drawings.

16.4.1 PCC 1:2:4 (1 cement : 2 sand : 4 coarse aggregate 20 mm nominal size) shall be measured in flooring of buildings, plinth protection, fencing, transformer/reactor foundation, rail track, drain, culverts, septic tank, chain link fencing, fencing gate ,external lighting poles etc. as indicated in the approved drawings.

16.4.2 PCC 1:4:8 (1 cement : 4 coarse sand : 8 stone aggregate, 40mm nominal size) shall be measured below all foundations of towers, equipment support structures, buildings, firefighting water tanks, covered car parking, cable trench, roads, under flooring, rail-cum-road, transformer foundation, reactor foundation, drain, cable trench crossings, culverts, fence, gate etc. as indicated in the approved drawings.

16.4.3 PCC 1:5:10 (1 Cement: 5 sand: 10 Stone aggregate, 40mm nominal size) shall be provided for site surfacing in switchyard, roof water proofing etc.

All other PCC required for the completion of the work including hold fasts of doors/windows/rolling shutters, fixing of plumbing pipes, bedding concrete for sewer lines, embedment of electrical conduits etc. shall not be measured and deemed included in the composite rates quoted by the bidder for respective works. Water proofing compound wherever specified shall be added without any extra cost.

16.5 **RCC**

Measurement of reinforced cement concrete at all locations shall be made and shall include all leads, lifts, formwork, grouting of pockets and underpinning, (but shall exclude reinforcement & miscellaneous structural steel like inserts etc.), of M25 design mix (Minimum). This shall also include pre-cast RCC work and addition of water proofing compound wherever required for which no additional payment shall be made. The quantity shall be measured in cubic meters as per lines and levels indicated in the drawings. No deduction shall be made for volume occupied by reinforcement/inserts/sleeves and for openings having cross-sectional area up to 0.1 Sq.M.

16.6 **Steel Reinforcement**

Reinforcement steel shall be measured in length (actual or theoretical as per drawing whichever is less) including hooks, if any, separately for different diameters as actually used in RCC work, excluding overlaps. From the length so measured, the weight of reinforcement shall be calculated in metric tonnes on the basis of sectional weights as adopted by British Standards/equivalent International standards. Wastage, overlaps, couplings, welded joints, spacer bars, chairs, stays, hangers and annealed steel wire or other methods for binding and placing shall not be measured and cost of these items shall be deemed to be included in the rates for reinforcement.

16.7 **Stone filling over grating in Transformer/Reactor foundation**

Measurement of stone (40mm nominal size) filling over gratings of transformer/reactor foundations shall be made as per theoretical volume of the space to be filled in the transformer foundation as per approved drawings. This shall be measured in Cu.M.

16.8 **Miscellaneous structural steel**

Measurement for Supply, fabrication, transportation and erection of all miscellaneous structural steel work for all gratings with supports for transformers/reactors , Cable trenches with covers (Chequered plate covers, cable supports, earthing cleats and edge protection angles etc), all other steel fittings and fixtures, inserts and embedment in concrete of transformer/reactor foundation and cable trenches shall be made as per approved drawings. The unit rate for this item shall be inclusive of cutting, grinding, drilling, bolting, welding, pre- heating of the welded joints, applying a priming coat of steel primer and anti-corrosive bitumastic paint/ synthetic enamel paint in general but with Zinc Phosphate Primer(Two packs) for grating and support for grating in Transformer /reactor foundation. (wherever specified), setting of all types of embedment in concrete, etc. Steel required for foundation bolts, nuts and bolt, doors, windows, ventilators, louvers, rolling shutters, chain link fencing, gratings in drains, soil pipes, plumbing pipes, floor traps, embedment's required for rainwater harvesting, septic tank, soak pit etc. shall not be considered for payment and measurements. Quantity shall be measured in metric tonnes.

16.9 **Roads**

The measurement for the concrete road shall be made on the basis of area in square meter (M^2) of top concrete completed surface of the road and shall be deemed to include all items such as excavation, compaction, rolling, watering, WBM, shoulder, etc. complete as per approved drawing but excluding concreting and reinforcement which shall be paid separately under respective items of BPS.

16.10 Anti-weed Treatment and Stone Spreading

The measurement shall be done for the actual area in square metres of stone spreading provided in the switchyard .It includes providing and spreading of 100mm thickness of uncrushed/crushed/broken stone of 40mm nominal size as per relevant BS codes/equivalent International standards for the specified area. Application of anti-weed treatment including material shall not be measured separately and item would be deemed to be included in the quoted rate of stone spreading in switchyard.

16.11 Chain Link Fencing and gate

The measurement shall be made in running metres of the fence provided as per approved drawing. The rate shall be including the post, fencing, MS Flat, painting, brick work and plaster of toe wall etc. complete but excluding the concrete. The switch yard gate shall be measured in numbers including all items except concrete and reinforcement.

16.12 **Cable Trenches and Cable trench Crossings**

Earthwork, PCC, RCC, reinforcement steel, RCC hume pipes and miscellaneous steel required for construction of Cable Trenches and cable trench crossings shall be measured under respective items of Bid price schedule (BPS) as described in clauses of aforesaid paras. No additional payment for brick work, plaster and PVC pipes used for cable trench crossings and sealing of trench mouth .

16.13 **Drains & Culverts**

PCC (1:2:4 and 1:4:8) for drains and culverts shall be measured under respective items of Bid price schedule (BPS) as described in clauses of aforesaid paras . All other items like excavation, backfilling, brick work, grating, plaster and stone pitching except RCC hume pipes required for completion of drains and culverts shall be deemed to be included in the quoted rate of drain. The quantity for each type of drain section shall be measured in running meters. However, RCC hume pipes used in culverts shall be measured under respective item of Bid price schedule (BPS) as described in clause of hume pipes.

16.14 Hume Pipe

Hume pipe shall be measured diameter-wise and laid as per approved drawings and shall be measured in running meters. The item shall be inclusive of excavation, laying, back filling, jointing etc. but excluding concrete and reinforcement (if any).

16.15 GIS Steel Building

Payment for this item shall be made on lump sum basis including internal foundations, cable trenches, internal & external finishes as well as internal Firefighting works etc. complete in all respect. However, the quantity of excavation, concrete, reinforcement shall be measured in respective items of BPS and described in above paras. The structural steel used for cable tray support, earthing cleat, chequered plates for internal cable trenches of building and panel room shall be measured and paid under miscellaneous steel item of BPS and described above paras. The rest of the entire work required to complete the building in all respect as per drawings prepared by contractor and approved by Owner shall be deemed to be included in this rate.

16.16 Rail cum Road

The measurement for the rail cum road shall be made in square metres of top concrete completed surface of the rail cum road and shall include all items such as excavation, compaction, rolling, watering, WBM etc. complete as per approved drawing but excluding concrete, reinforcement, structural steel and rails with rail fixing details which shall be measured separately under respective item of BPS and described in above paras.

16.17 Water supply system

The water supply system shall be measured in lumpsum basis including supply system from bore-well to buildings and internal distribution on buildings. It shall include all the items such as excavation, piping, pipe fittings, water tank, painting, brickwork, sand filling, concrete, valves, chambers cutting chases in walls, openings in RCC and repairs, etc. required to complete the job.

16.18 Digging of Bore well

Digging of Bore well shall be measured in running meter starting from ground level including PVC pipe, GI pipe, 3 HP submersible pump set with necessary cables, control boards, protective devices etc. all complete.

16.19 External Sewage System

It shall be measured in lumpsum basis. It shall include all the items such as excavation, piping, pipe fittings, manholes, gali trap, gali chamber casing in concrete and repairs, septic tank, soak pit etc required to complete the job but concrete and reinforcement used for septic tank and soak pit shall be paid separately. Any modification in the existing sewage system, if required, shall be done by the Contractor without any extra cost implicated to Owner.

16.20 Two Story RCC Control Building

Payment for this item shall be made on lump sum basis including internal foundations, cable trenches, internal & external finishes as well as internal Firefighting works, water proofing treatment for roof/terrace etc. complete in all respect. However, the quantity of excavation, concrete, reinforcement shall be measured in respective items of BPS and described in above paras. The structural steel used for cable tray support, earthing cleat, chequered plates for internal cable trenches of building shall be measured and paid under miscellaneous steel item of BPS and described above paras. The rest of the entire work required to complete the building in all respect as per drawings prepared by contractor and approved by Owner shall be deemed to be included in this rate.

16.21 Diesel Generator (DG) Enclosure

Payment for this item shall be made on lump sum basis for the entire civil works associated complete in all respect as per drawings prepared by contractor and approved by Owner shall be deemed to be included in this rate. However, the quantity of excavation, concrete, reinforcement shall be measured in respective items of BPS and described in above paras.

16.22 Slope Protection Work

Slope protection work by stone pitching and by Bio engineering grass plantation shall be measure in square meter including all work required to complete the work as per technical specification.

17.0 MISCELLANEOUS GENERAL REQUIREMENTS

17.1 Dense concrete with controlled water cement ratio as per BS-code/IS code/equivalent international standard shall be used for all underground concrete structures such as cable and pipe trenches etc. for achieving water-tightness.

17.2 All joints including construction and expansion joints for the water retaining structures shall be made water tight by using PVC ribbed water stops with central bulb. However, kicker type (externally placed) PVC water stops shall be used for the base slab and in other areas where it is required to facilitate concreting. The minimum thickness of PVC water stops shall be 5 mm and minimum width shall be 230 mm.

17.3 All steel sections and fabricated structures which are required to be transported on sea shall be provided with anti-corrosive paint to take care of sea worthiness.

17.4 All mild steel parts used in the water retaining structures shall be hot-double dip galvanised. The minimum coating of the zinc shall be 750 gm/sq. m. for galvanised structures and shall comply with relevant BS. Galvanizing shall be checked and tested in accordance with relevant BS. The galvanizing shall be followed by the application of an etching primer and dipping in black bitumen in accordance with BS:3416.

17.5 Bricks having minimum 75 kg/cm2 compressive strength can only be used for masonry work. Contractor shall ascertain himself at site regarding the availability of bricks of minimum 75 kg/cm2 compressive strength before submitting his offer.

17.6 Doors and windows on external walls of the buildings (other than areas provided, with insulated metal claddings) shall be provided with RCC sun-shade over the openings with 300 mm projection on either side of the openings. Projection of sunshade from the wall shall be minimum 450 mm over window openings and 750 mm over door openings.

17.7 All stairs shall have maximum riser height of 150 mm and a minimum tread width of 300 mm. Minimum width of stairs shall be 1500 mm. Service ladder shall be provided for access to all roofs. RCC fire escape staircase if required as per local bye laws, shall be provided in GIS buildings.

17.8 Angles 50x50x6 mm (minimum) with lugs shall be provided for edge protection all round cut outs/openings in floor slab, edges of drains supporting grating covers, edges of RCC cable/pipe trenches supporting covers, edges of manholes supporting covers, supporting edges of manhole precast cover and any other place where breakage of corners of concrete is expected.

17.9 Anti termite chemical treatment for buildings shall be given to all column pits, wall trenches, foundations, filling below the floors etc. as per relevant International/BS .

17.10 Hand-railing minimum 1200mm high shall be provided around all floor/roof openings, projections/balconies, walk ways, platforms, steel stairs etc. All handrails and ladder pipes shall be 32 mm nominal bore MS pipes (medium class) and shall be galvanised (medium-class as per relevant BS). All rungs for ladder shall also be galvanised as per relevant BS.

For RCC stairs, stainless steel hand railing shall be provided.

17.11 For all civil works covered under this specification, design Mix of Minimum M25 grade as per relevant International /BS/IS shall be used. Reinforcement steel shall be of minimum Fe 500 grade.

The material specification, workmanship and acceptance criteria shall be as per relevant clauses of applicable International/BS/IS standard.

17.12 Items/components of buildings not explicitly covered in the specification and BPS but required for completion of the project shall be deemed to be included in the scope.

17.13 Requirement of sulphate resistant cement (SRC) for sub structural works shall be decided in accordance with the International/BS/IS Standards based on the findings of the detailed soil investigation to be carried out by the Bidder.

17.14 Foundation system adopted by Bidder shall ensure that relative settlement and other criteria shall be as per provision in relevant BS/IS/Equivalent International Standards.

17.15 Construction joints shall be as per International/BS/IS standard

17.16 All building/construction materials shall conform to the best quality specified in relevant International /BS/IS standard.

18.0 INTERFACING

The proper coordination & execution of all interfacing civil works activities like fixing of conduits in roofs/walls/floors, fixing of foundation bolts, fixing of lighting fixtures, fixing of supports/embedments, provision of cut outs etc. shall be the sole responsibility of the Contractor. He shall plan all such activities in advance and execute in such a manner that interfacing activities do not become bottlenecks and dismantling, breakage etc. is reduced to minimum.

19.0 STATUTORY RULES

19.1 Contractor shall comply with all the applicable statutory rules pertaining to relevant acts of GoN.

19.2 Provisions for fire proof doors, no. of staircases, fire escape stairs ,fire separation wall, plastering on structural members (in fire prone areas) etc. shall be made according to the recommendations of Engineer In charge.

19.3 Statutory clearance and norms of Local Pollution Control Board shall be followed as per Water Resources Act for effluent quality from plant.

20.0 FIELD QUALITY PLAN

All tests as required in accordance to BS codes or equivalent International standards have to be carried out. The contractor shall prepare field quality plan for civil works as per relevant /BS codes/IS/equivalent International Standards during detailed engineering stage and submit to Owner for approval within ONE month after award of work.

21.0 SITE SPECIAL CONDITION

There are some special condition to be fulfilled by contractor during the construction of Hetauda 400 kv GIS substation and Inaruwa 400 KV GIS substation which are described in Annex- A and Annex-B respectively.

22.0 STANDARD CODES

For design and engineering relevant British Standard Codes (BS Codes)/Indian Standard Codes (IS Codes) or equivalent International standards shall be referred by the contractor. Relevant portion of British Standard Codes (BS Codes)/Indian Standard Codes (IS Codes) or equivalent International standards referred by the contractor for the design shall be made available to Owner if necessary during detailed engineering stage.

ANNEX –A: SPECIAL CONDITION FOR HETAUDA 400 KV SUBSTATION

1. Diversion of Existing RCC Drain and Construction of New RCC Drain

1.1 SCOPE OF WORK

The Contractor shall furnish all labour, equipment and materials required for complete performance of the work in accordance with the drawings, Specification. Dismantling of existing RCC drain as per existing drawing including sorting and stacking of serviceable & non-serviceable materials, disposal of debris and backfilling of drain fall under the present scope of work.
Construction of new RCC drain to divert existing drain as per drawing provided along with tender document fall under the present scope of work.

1.2 Dismantling of existing RCC Drain and Removal of Hume Pipe

RCC drain and hume pipe is running through midway of switchyard area which should be dismantled and backfill with appropriate material and should be well compacted. All the serviceable and non-serviceable material should be stack at suitable place as per site incharge instruction.
The drain shall be backfill by earth and compacted to minimum 95% of the Standard Proctor's density at OMC. Backfill material shall be placed in successive uniform horizontal layers not exceeding 30 cm in thickness in loose stage measurement and compacted to the requirement.

Measurement

Dismantling of existing RCC drain and removal of hume pipe are measured separately in running meter including sorting and stacking of serviceable & non-serviceable materials, disposal of debris. Backfilling for that area is not measured separately which shall be included on site levelling work.

1.3 Construction of New RCC Drain

The scope of this work includes the design, engineering and construction of new RCC closed drain. The layout of drain is shown on the layout of Hetauda 400 kv substation provided along with tender document but the section of drain shown is only for tender purpose. Contractor shall optimise the size of new RCC closed drain and shall submit design and drawing to the employer for approval. At the entry and exit of the drain there shall be appropriate size of RCC catch pit as per the site condition.

Measurement

No separate measurement shall be made for RCC drain. Earthwork in excavation, concrete work and reinforcement work shall be measure and paid separately under respective items of BPS.

ANNEX –B: SPECIAL CONDITION FOR INARUWA 400 KV SUBSTATION

A. PROBLEM OF LIQUEFACTION AND ITS MITIGATION

Soil investigation carried out at Inaruwa 400kv GIS substation site shows that there is liquefaction problem on soil during the large earthquake. It shall be the contractor scope to mitigate the liquefaction problem as recommended by soil investigation agency, "Soil, Rock and Concrete Laboratory, NEA".

As per the recommendation of soil testing agency liquefaction susceptibility is seen upto 7.0m depth for large earth earthquake like India-Nepal earthquake of 1934 (Ms -8.4) from ground level that can be minimized by providing 700mm dia. 7.0m length gravel pile/stone columns at 2.1m c/c spacing beneath the foundation structure at the sub-station project site.

The soil investigation report given by "Soil, Rock and Concrete Laboratory, NEA" is attached on Apendix-1 of this chapter.

B. METHODOLOGY AND SPECIFICATION FOR INSTALLATION OF STONE COLUMNS AS RECOMMENDATED BY "SOIL, ROCK AND CONCRETE LABORATORY".

1. GENERAL

As per the previous Soil Investigation works carried out at the substation site it is found liquefaction seismic hazards which contribute to the sinking or tilting of heavy structures, settlement of building, lateral spreading and retaining wall failure. Similarly, ground surface settlement, sand boils and post-earthquake stability failures can be developed at level ground surfaces.
Here a short mitigation measures adopting ground improvement techniques of stone columns/gravel piles has been found quite economical and faster in construction. The proposed unit minimizes the buildup of pore water pressure during earthquakes by shortening the drainage paths in a soil deposits. The installation of drains generally involves some degree of densification and the drains themselves may also provide some reinforcement. From the above assessment the site could be improved against liquefaction susceptibility.

2. Objective

The main objective of the installation of stone column/gravel piles are;

i) To dissipate the pore water pressure from the surrounding liquefiable soil mass through vertical drains.

ii) To increase strength (Bearing Capacity) by increasing the densities of the soil mass.

3. Scope of the work

The main scope of the works is:

i) The installation of stone columns/gravel piles by drilling, charging and compaction of crushed granular materials by any appropriate method.
ii) Measurement/ verification of soil improvement by fields and lab test results.

4. Methodology / Construction Techniques

The process of installation of stone column is,

I) Grading of Granular Materials

1) 50mm down manufactured graded coarse aggregate or natural river bed materials (pebbles, gravels, fine gravels and coarse to fine sands etc.) is used as a filling materials as a Gradation Table.

Table

Size (mm)	% fine by weight
75	90 – 100
50	89 – 90
38	55 – 75
20	10 – 20
12	5 – 13
2	15
Sand	2 – 5 % by weight

2) Filling granular materials would be free from any harmful ingredients (i.e. vegetable matters, clay lumps, cobbles and boulders).

II) Making a Bore Holes

1) The bore holes are made by Helical Auger Boring or Bailer & Casing Method (IS 15284, Part I, Annex-c) throughout the mentioned 7.0m depth as per requirement.

a) Helical Auger Boring Method:

The bores are made with machine/manually operated augers supported on tripods. Bentonite slurry was provided while drilling whenever required to prevent caving of the bore hole sides. The bores are driven to a depth of 7.0m (as per drawing and instruction of project Engineer).

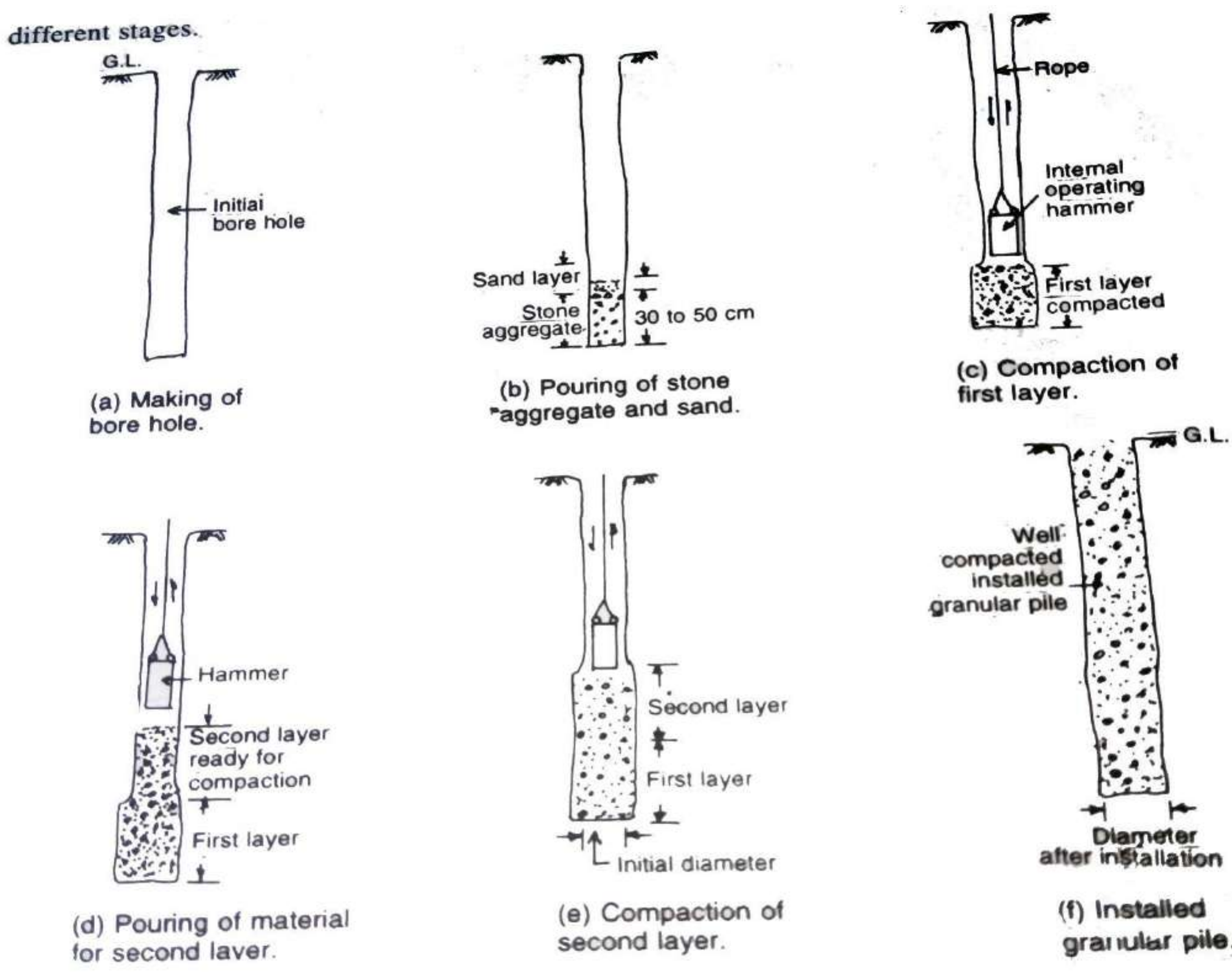
b) Bailer & Casing Method:

In case augers did not work then boring are done with bailers using a mechanical winch rotating by a powerful engine up to required 7.0m depths through steel casing / lining with bentonite slurry.
Finally, the bore hole should be cleaned/ cleared mechanically drilling before charging the filling granular materials.

III) Filling and Compaction of Granular Materials

1) The bore holes are charged by granular filling materials layer by layer having 30 cm ht. with regular 0.04m3 (two buckets) in each interval and then compaction is proceed by 300 kg or above wt. of hammer/rammer about 5 times from 1.5 m ht by mechanical winch fitted machine. The depth of filling shall vary as per type of structure footing to be constructed on it and instruction of project Engineer.
In case of temporary liner of bailer boring, compaction may be done in stages upto bottom of liner and should be raised and further compaction done.
2) The density of the compacted granular materials should be greater than 70% degree of compaction.
3) The site should be supervised and frequently checked as per standards by a well-known Geo-Technical Engineer during the period of construction.
4) After the installation of stone column the rig is moved to the another point to make a bore hole and that space is left open for the foundation work.

The complete process will be as given below sequentially in a figure:



Granular pile installation method

5. Analysis of Installation / Results and Recommendation

Problems:

❖ From the liquefaction analysis report the liquefaction susceptibility has been seen upto 7.0m depth in sub-station site area.

Mitigation Measures:

❖ Stone piling work shall be carried out under the foundations of Towers, Power Transformer, heavy equipment structures and buildings. The spacing of piles shall be @2.1mC/C under heavy structures footing as per foundation layout plan during construction.

- ❖ Stone Pile cutoff level shall be 300mm below the founding Level. Above stone pile cut off level a compacted layer of 300mm thick graded granular material mixed with local sand shall be provided.

6. Verification of Test Report

The following tests will be carried out in every 250 m^2 in the presence of Consultant/NEA Engineer and later verified accordingly.

- Initial and routine test shall be carried out as per IS: 15284- Part1- clause No: 13.4 & 13.7 (k) after completion of stone piling work.
- Others essential field and laboratory test such as lab test of gradation of granular material, permeability of surrounding soil, compaction test and field test for relative density and SPT/CPT test shall be carried out as per BS/IS or equivalent international standard.

C. MEASUREMENT

- Boring or drilling of 700mm dia. bore for stone column as per IS:15284(pt-1):2000 by means of auger or bailer casing method either mechanically or manually, including all labour T&P, bentonite or temporary casing ,all materials etc. complete as per site condition upto a depth of 7.0m from NGL shall be measured in running meter.
- Providing and charging of the stone column bore by using 50mm down graded granular crushed material as per specification. The granular material shall be compacted by using percussion machine with 300 kg or above hammering arrangement as per specification .The rate includes all above operations, supply of all materials, labour, T&P transportation, royalty etc. The compacted layer with original dia. 700mm only shall be measured for the payment purpose. The measurement shall be made in cubic meter.
- 300 mm thick granular blanket provided at cutoff level of stone column shall be measured in cubic meter. The rate includes all operations, supply of all materials, labour, T&P transportation, royalty etc.
- Measurement of different test shall be made as per BOQ.

Appendix 1

Soil investigation report given by "Soil, Rock and Concrete Laboratory, NEA" for Inaruwa Substation

CHAPTER 17: CONTROL, RELAY & PROTECTION PANELS

1. TYPE OF PANELS

1.1 Simplex Panel

Simplex panel shall consist of a vertical front panel with equipment mounted thereon and having wiring access from rear for control panels & front for relay/protection/**Interface** panels. In case of panel having width more than 800mm, double leaf-doors shall be provided. Doors shall have handles with built-in locking facility.

2. CONSTRUCTIONAL FEATURES

2.1. Control and Relay Board shall be **simplex type**. It is the responsibility of the Contractor to ensure that the equipment specified and such unspecified complementary equipment required for completeness of the protective/control schemes be properly accommodated in the panels without congestion and if necessary, either more number of panels or panels with larger dimensions **shall be provided (as per panel layout requirement)**. No price increase at a later date on this account shall be allowed. However, the width of panels that are being offered to be placed in existing switchyard control rooms, should be in conformity with the space availability in the control room.

2.2. Panels shall be completely metal enclosed and shall be dust, moisture and vermin proof. The enclosure shall provide a degree of protection not less than IP-31 in accordance with IEC 60529 (Part-1)

2.3. Panels shall be free standing, floor mounting type and shall comprise structural frames completely enclosed with specially selected smooth finished, cold rolled sheet steel of thickness not less than 3 mm for weight bearing members of the panels such as base frame, front sheet and door frames, and 2.0mm for sides, door, top and bottom portions. There shall be sufficient reinforcement to provide level transportation and installation.

2.4. All doors, removable covers of panels shall be gasketed all around with synthetic gaskets Neoprene/EPDM. However, XLPE gaskets can also be used for fixing protective glass doors. Ventilating louvers, if provided shall have screens and filters. The screens shall be made of either brass or GI wire mesh.

2.5. Design, materials selection and workmanship shall be such as to result in neat appearance, inside and outside with no welds, rivets or bolt head apparent from outside, with all exterior surfaces tune and smooth.

2.6. Panels shall have base frame with smooth bearing surface, which shall be fixed on the embedded foundation channels/insert plates. Anti-vibration strips made of shock absorbing materials that shall be supplied by the contractor, which shall be placed between panel & base frame.

2.7. Cable entries to the panels shall be from the bottom. Cable gland plate fitted on the bottom of the panel shall be connected to earthing of the panel/station through a flexible braided copper conductor rigidly.

2.8. Relay/protection panels of modern modular construction **meeting the functional requirement** would also be acceptable.

3. MOUNTING

3.1. All equipment on and in panels shall be mounted and completely wired to the terminal blocks ready for external connections. The equipment on front of panel shall be mounted flush.

3.2. Equipment shall be mounted such that removal and replacement can be accomplished individually without interruption of service to adjacent devices and are readily accessible without use of special tools. Terminal marking on the equipment shall be clearly visible.

3.3. The Contractor shall carry out cut out, mounting and wiring of the free issue items supplied by others which are to be mounted in his panel in accordance with the corresponding equipment manufacturer's drawings. Cut outs if any, provided for future mounting of equipment shall be properly blanked off with blanking plate.

3.4. The centre lines of switches, push buttons and indicating lamps shall be **preferably** not less than 750mm from the bottom of the panel. The centre lines of relays, meters and recorders shall be **preferably** not less than 450mm from the bottom of the panel.

3.5. The centre lines of switches, push buttons and indicating lamps shall be matched to give a neat and uniform appearance. Like wise the top lines of all meters, relays and recorders etc. shall be matched.

3.6. No equipment shall be mounted on the doors.

3.7. At existing station, panels shall be matched with other panels in the control room in respect of dimensions, colour, appearance and arrangement of equipment (centre lines of switches, push buttons and other equipment) on the front of the panel.

4. PANEL INTERNAL WIRING

4.1. Panels shall be supplied complete with interconnecting wiring provided between all electrical devices mounted and wired in the panels and between the devices and terminal blocks for the devices to be connected to equipment outside the panels. When panels are arranged to be located adjacent to each other all inter panel wiring and connections between the panels shall be carried out internally.

4.2. All wiring shall be carried out with 650V grade, single core, stranded copper conductor wires with PVC insulation. The minimum size of the multi-stranded copper conductor used for internal wiring shall be as follows:

- All circuits except current transformer circuits and voltage **transformer** circuits meant for energy metering - one 1.5mm sq. per lead.
- All current transformer circuits - one 2.5 sq.mm per lead.

- Voltage transformer circuit (for energy meters): Two 2.5 mm sq. per lead.

4.3. All internal wiring including FO patch cords shall be securely supported, neatly arranged, readily accessible and connected to equipment terminals and terminal blocks. Wiring gutters & troughs shall be used for this purpose.

4.4. Void

4.5. Wire termination shall be made with solderless crimping type and tinned copper lugs, which firmly grip the conductor. Insulated sleeves shall be provided at all the wire terminations. Core identification plastic ferrules marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. Ferrules shall fit tightly on the wire and shall not fall off when the wire is disconnected from terminal blocks. All wires directly connected to trip circuit breaker or device shall be distinguished by the addition of red coloured unlettered ferrule.

4.6. Longitudinal troughs extending throughout the full length of the panel shall be preferred for inter panel wiring. Inter-connections to adjacent panel shall be brought out to a separate set of terminal blocks located near the slots of holes meant for taking the inter-connecting wires. **Wiring termination at interface panel end shall be through prefabricated plug-in type connectors.**

4.7. Contractor shall be solely responsible for the completeness and correctness of the internal wiring and for the proper functioning of the connected equipments.

5. TERMINAL BLOCKS

5.1. All internal wiring to be connected to external equipment shall terminate on terminal blocks. Terminal blocks shall be 650 V grade and have 10 Amps. Continuous rating, moulded piece, complete with insulated barriers, stud type terminals, washers, nuts and lock nuts. Markings on the terminal blocks shall correspond to wire number and terminal numbers on the wiring diagrams. All terminal blocks shall have shrouding with transparent unbreakable material.

5.2. Disconnecting type terminal blocks for current transformer and voltage transformer secondary leads shall be provided. Also current transformer secondary leads shall be provided with short circuiting and earthing facilities.

5.3. At least 20% spare terminals shall be provided on each panel and these spare terminals shall be uniformly distributed on all terminal blocks.

5.4. Unless otherwise specified, terminal blocks shall be suitable for connecting the following conductors of external cable on each side

- All CT & PT circuits: minimum of two no. of 2.5mm Sq. copper.
- AC/DC Power Supply Circuits: **two** no. of **16mm** Sq. Aluminium.
- All other circuits: minimum of one no. of 2.5mm Sq. Copper.

5.5. There shall be an **approximate clearance** of 250mm between the first row of terminal blocks and the associated cable gland plate or panel side wall. **Similarly** the clearance between two rows of terminal blocks edges shall be of 150mm **approximate**.

5.6. Arrangement of the terminal block assemblies and the wiring channel within the enclosure shall be such that a row of terminal blocks is run in parallel and close proximity along each side of the wiring-duct to provide for convenient attachment of internal panel wiring. The side of the terminal block opposite the wiring duct shall be reserved for the external cable connections. All adjacent terminal blocks shall also share this field wiring corridor. All wiring shall be provided with adequate support inside the panels to hold them firmly and to enable free and flexible termination without causing strain on terminals.

5.7. The number and sizes of the Owner's multi core incoming external cables will be furnished to the Contractor after placement of the order. All necessary cable terminating accessories such as gland plates, supporting clamps & brackets, wiring troughs and gutters etc. (except glands & lugs) for external cables shall be included in the scope of supply. **Terminal blocks provided on Interface panel used for external wiring from switchyard shall be provided with necessary surge protection device to safeguard IEDs from transient voltage surges, spikes.**

6. PAINTING

The painting shall be carried out as detailed in Chapter 2–GTR.

7. MIMIC DIAGRAM (FOR CONTROL PANELS)

7.1. Coloured mimic diagram and symbols showing the exact representation of the system shall be provided in the front of control panels.

7.2. Mimic diagram shall be made preferably of anodised aluminium or plastic of approved fast colour material, which shall be screwed on to the panel and can be easily cleaned. The mimic bus shall be 2mm thick. The width of the mimic bus shall be 10mm for bus bars and 7mm for other connections. Painted overlaid mimic is also acceptable.

7.3. Mimic bus colour will be decided during detailed Engineering.

7.4. When semaphore indicators are used for equipment position, they shall be so mounted in the mimic that the equipment in close position shall complete the continuity of mimic.

7.5. Indicating lamp, one for each phase, for each bus shall be provided on the mimic to indicate bus charged condition

8. NAME PLATES AND MARKINGS

8.1. All equipment mounted on front and rear side as well as equipment mounted inside the panels shall be provided with individual name plates with equipment designation engraved. Also on the top of each panel on front as well as rear side, large and bold nameplates shall be provided for circuit/feeder designation.

8.2. All front mounted equipment shall also be provided at the rear with individual name plates engraved with tag numbers corresponding to the one shown in the panel internal wiring to facilitate easy tracing of the wiring.

8.3. Each instrument and meter shall be prominently marked with the quantity measured e.g. kV, A, MW, etc. All relays and other devices shall be clearly marked with manufacturer's name, manufacturer's type and electrical rating data.

8.4. Name Plates shall be made of non-rusting metal or 3 ply lamicoid. Name plates shall be black with white engraving lettering.

8.5. Each switch shall bear clear inscription identifying its function e.g. 'BREAKER' '52A', "SYNCHRONISING" etc. Similar inscription shall also be provided on each device whose function is not other-wise identified. If any switch device does not bear this inscription separate name plate giving its function shall be provided for it. Switch shall also have clear inscription for each position indication e.g. "Trip- Neutral-Close", "ON-OFF", "R-Y-B-OFF" etc.

8.6. All the panels shall be provided with name plate mounted inside the panel bearing LOA No & Date, Name of the Substation & feeder and reference drawing number.

9. MISCELLANEOUS ACCESSORIES

9.1. **Plug Point**: 230V, Single phase 50Hz, AC socket with switch suitable to accept 5 Amps and 15 Amps pin round standard plug, shall be provided in the interior of each cubicle with ON-OFF switch.

9.2. **Interior Lighting**: Each panel shall be provided with a **LED type lighting fixture (Min 7 Watt)** rated for 230 Volts, single phase, 50 Hz supply for the interior illumination of the panel controlled by the respective panel door switch. Adequate lighting shall also be provided for the corridor in Duplex panels.

9.3. **Switches and Fuses:** Each panel shall be provided with necessary arrangements for receiving, distributing and isolating of DC and AC supplies for various control, signaling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with Fuses. Selection of the main and sub-circuit Fuses rating shall be such as to ensure selective clearance of sub-circuit faults. Voltage transformer circuits for relaying and metering shall be protected by fuses. All fuses shall be HRC cartridge type conforming to relevant international standard. The short time fuse rating of Fuses shall be not less than 9 KA. Fuse carrier base shall have imprints of the fuse 'rating' and 'voltage'. MCB's shall also accepted for protecting the relaying and metering circuits instead of HRC Fuse.

9.4. **Space Heater**: Each panel shall be provided with a thermostatically **controlled** space heater rated for 230V, single phase, 50 Hz AC supply for the internal heating of the panel to prevent condensation of moisture. The fittings shall be complete with switch unit.

10. EARTHING

10.1. All panels shall be equipped with an earth bus securely fixed. Location of earth bus shall ensure no radiation interference from earth systems under various switching conditions of isolators and breakers. The material and the sizes of the bus bar shall be at least 25 X 6 sq.mm copper with threaded holes at a gap of 50 mm with provision of bolts and nuts for connection with cable armours and mounted equipment etc for effective earthing. When several panels are mounted adjoining each other, the earth bus shall be made continuous and necessary connectors and clamps for this purpose shall be included in the scope of supply of Contractor. Provision shall be made for extending the earth bus bars to future adjoining panels on either side.

10.2. Provision shall be made on each bus bar of the end panels for connecting Substation earthing grid. Necessary terminal clamps and connectors for this purpose shall be included in the scope of supply of Contractor.

10.3. All metallic cases of relays, instruments and other panel mounted equipment including gland plate, shall be connected to the earth bus by copper wires of size not less than 2.5 sq. mm. The colour code of earthing wires shall be green.

10.4. Looping of earth connections which would result in loss of earth connection to other devices when the loop is broken, shall not be permitted. However, looping of earth connections between equipment to provide alternative paths to earth bus shall be provided.

10.5. VT and CT secondary neutral or common lead shall be earthed at one place only at the terminal blocks where they enter the panel. Such earthing shall be made through links so that earthing may be removed from one group without disturbing continuity of earthing system for other groups.

10.6. An electrostatic discharge arrangement shall be provided in each panel so as to discharge human body before he handles the equipments inside the panels.

11. INDICATING INSTRUMENTS & TRANSDUCERS FOR CONTROLPANEL

All instruments, meters and transducers shall be enclosed in dust proof, moisture resistant, black finished cases and shall be suitable for tropical use. All Megawatt, Megavar, voltage and frequency indicating instruments shall be provided with individual transducers and these shall be calibrated along with transducers to read directly the primary quantities. They shall be accurately adjusted and calibrated at works and shall have means of calibration check and adjustment at site. The supplier shall submit calibration certificates at the time of delivery. However n o separate transducers are envisaged for digital bus voltmeters and digital frequency meters and the indicating meters provided in the synchronising equipment.

11.1. Indicating Instruments

11.1.1. Unless otherwise specified, all electrical indicating instruments shall be of digital type suitable for flush mounting.

11.1.2. Instruments shall have 4-digit display; display height being not less than 25 mm.

11.1.3. Instrument shall confirm to relevant IEC and shall have an accuracy class of 1.5 or better. Watt and Var meters shall have an indication of (+) and (-) to indicate EXPORT and IMPORT respectively.

11.1.4. Digital voltage and frequency meters shall be of class: 0.5 and shall have digital display of **4** and ***4*.5** digits respectively, with display size, not less than 25mm (height).

11.2. Transducers

11.2.1. Transducers (for use with Indicating Instruments and Telemetry/Data Communication application) shall in general conform to IEC:60688-1.

11.2.2. The transducers shall be suitable for measurement of active power, reactive power, voltage, current and frequency in three phase four wire unbalanced system.

11.2.3. The input to the transducers will be from sub-station current & potential transformers. The output shall be in milli ampere D.C. proportional to the input & it shall be possible to feed the output current directly to the telemetry terminal or indicating instruments.

11.2.4. The transducer characteristic shall be linear throughout the measuring range.

11.2.5. The transducer output shall be load independent.

11.2.6. The input & output of the transducer shall be galvanically isolated.

11.2.7. Each transducer shall be housed in a separate compact case and have suitable terminals for inputs & outputs.

11.2.8. The transducers shall be suitably protected against transient high peaks of voltage & current.

11.2.9. The transducer shall withstand indefinitely without damage and work satisfactorily at 120% of the rated voltage and 120% of the rated input current as applicable.

11.2.10. All the transducers shall have an output of 4-20 mA.

11.2.11. The response time of the transducers shall be less than 1 second.

11.2.12. The accuracy class of transducers shall be 1.0 or better for voltage/current transducer, 0.5 or better for watt/VAR transducer and 0.2 or better for frequency transducer.

11.2.13. The transducers shall have a low AC ripple on output less than 1%.

11.2.14. The transducer shall have dual output.

12. ANNUNCIATION SYSTEM for Control Panel

12.1. Alarm annunciation system shall be provided in the control board by means of visual and audible alarm in order to draw the attention of the operator to the abnormal operating conditions or the operation of some protective devices. The annunciation equipment shall be suitable for operation on the voltages specified in this specification.

12.2. The visual annunciation shall be provided by annunciation facia, mounted flush on the top of the control panels.

12.3. The annunciation facia shall be provided with translucent plastic window for alarm point with approximate size of 35mm x 50mm. The facia plates shall be engraved in black lettering with respective inscriptions. Alarm inscriptions shall be engraved on each window in not more than three lines and size of the lettering shall not be less than 5 mm.

12.4. Each annunciation window shall be provided with two white lamps in parallel to provide safety against lamp failure. Long life lamps shall be used. The transparency of cover plates and wattage of the lamps provided in the facia windows shall be adequate to ensure clear visibility of the inscriptions in the control room having high illumination intensity (350 Lux), from the location of the operator's desk.

12.5. All Trip facia shall have red colour and all Non-trip facia shall have white colour.

12.6. The audible alarm shall be provided by Buzzer/ Hooter /Bell having different sounds and shall be used as follows.

Hooter	Alarm Annunciation
Bell	Annunciation DC failure
Buzzer	AC supply failure

12.7. Sequence of operation of the annunciator shall be as follows:

Sl NO.	Alarm Condition	Fault Contact	Visual Annunciation	Audible Annunciation
1.	Normal	Open	OFF	OFF
2.	Abnormal	Close	Flashing	ON
3.	Accept Push	Close	Steady On	OFF
	Button Pressed	Open	Steady On	OFF
4.	Reset Push Button	Close	On	OFF
	Pressed	Open	Off	OFF
5.	Lamp Test Push Button Pressed	Open	Steady On	OFF

12.8. Audible annunciation for the failure of DC supply to the annunciation system shall be provided and this annunciation shall operate on 230 Volts AC supply. On failure of the DC to the annunciation system for more than 2 or 3 seconds (adjustable setting), a bell shall sound. A separate push button shall be provided for the cancellation of this audible alarm alone but the facia window shall remain steadily lighted till the supply to annunciation system is restored.

12.9. A separate voltage check relay shall be provided to monitor the failure of supply (230V AC) to the scheme mentioned in Clause above. If the failure of supply exists for more than 2 to 3 seconds, this relay shall initiate visual and audible annunciation. Visual and audible annunciation for the failure of AC supply to the annunciation system shall be provided and this annunciation shall operate on Annunciation DC and buzzer shall sound.

12.10. The annunciation system described above shall meet the following additional requirements :

a) The annunciation system shall be capable of catering to at least 20 simultaneous signals at a time.

b) One set of the following push buttons shall be provided on each control panel:

- Reset push button for annunciation system
- Accept push button for annunciation system
- Lamp test push button for testing the facia windows

c) One set of the following items shall be provided common for all the control panel (not applicable for extension of substation):

- Flasher relay for annunciation system
- Push button for Flasher test
- Three Push buttons for test of all audible alarm systems

d) These testing circuits shall be so connected that while testing is being done, it shall not prevent the registering of any new annunciation that may land during the test.

e) The annunciation shall be repetitive type and shall be capable of registering the fleeting signal. Minimum duration of the fleeting signal registered by the system shall be 15 milli seconds.

f) In case of static annunciator scheme, special precaution shall be taken to ensure that spurious alarm condition does not appear due to influence of external electromagnetic/ electrostatic interference on the annunciator wiring and switching disturbances from the neighbouring circuits within the panels and the static annunciator shall meet the high voltage susceptibility test , impulse voltage with stand test , high frequency disturbance test– class III and fast transient disturbance test –level III as per IEC 60255.

12.11. The annunciation system to be supplied for existing sub-stations shall be engineered as an extension to the existing scheme.

12.12. For the Control panel with BCU (if envisaged in Chapter-PSR), only common alarm lamp shall be provided for each Control panel. Each BCU of the control panel shall energize this common alarm lamp on occurrence of alarms/Trips. All alarms shall be available in the BCU mimic/HMI.

13. SWITCHES

13.1. Control and instrument switches shall be rotary operated type with escutcheon plates clearly marked to show operating position and circuit designation plates and suitable for flush mounting with only switch front plate and operating handle projecting out.

13.2. The selection of operating handles for the different types of switches shall be as follows:

Breaker, Isolator control Switches : Pistol grip, black

Synchronising switches	:	Oval, Black, Keyed handle (one common removable handle for a group of switches or locking facility having common key)
Synchronising Selector switches	:	Oval or knob, black
Instrument switches	:	Round, knurled, black

Protection Transfer switch, **Local / remote selector switch**: Pistol grip, lockable and black.

13.3. The control switch of breaker and isolator shall be of spring return to neutral type. The switch shall have spring return from close and trip positions to "after close" and "after trip" positions respectively.

13.4. Protection Transfer switch / BCU will energise a bi-stable relay for protection transfer function from local/ remote HMI.

13.5. Instrument selection switches shall be of maintained contact (stay put) type. Ammeter selection switches shall have make-before-break type contacts so as to prevent open circuiting of CT secondary when changing the position of the switch. Voltmeter transfer switches for AC shall be suitable for reading all line- to-line and line-to-neutral voltages for non- effectively earthed systems and for reading all line to line voltages for effectively earthed systems.

13.6. Synchronising switches shall be of maintained contact (stay put) type having a common removable handle for a group of switches. The handle shall be removable only in the OFF position and it shall be co-ordinated to fit in to all the synchronising switches. These switches shall be arranged to connect the synchronising equipment when turned to the
'ON' position. One contact of each switch shall be connected in the closing circuit of the respective breaker so that the breaker cannot be closed until the switch is turned to the 'ON' position.

13.7. Lockable type of switches which can be locked in particular positions shall be provided when specified. The key locks shall be fitted on the operating handles.

13.8. The contacts of all switches shall preferably open and close with snap action to minimise arcing. Contacts of switches shall be spring assisted and contact faces shall be with rivets of pure silver or silver alloy. Springs shall not be used as current carrying parts

13.9. The contact combination and their operation shall be such as to give completeness to the interlock and function of the scheme.

13.10. The contact rating of the switches shall be as follows :

Description	Contact Rating in Amps		
	220V DC	50V DC	230V AC
Make and carry continuously	10	10	10
Make and carry for 0.5 sec.	30	30	30
Break for Resistive load	3	20	7
Break for Inductive load - with L/R = 40m sec.	0.2	-	

14. INDICATING LAMPS

14.1. Indicating lamps shall be of cluster LED type suitable for panel mounting with rear terminal connections. Lamps shall be provided with series connected resistors preferably built in the lamp assembly. Lamps shall have translucent lamp covers to diffuse lights coloured red, green, amber, clear white or blue as specified. The lamp cover shall be preferably of screwed type, unbreakable and moulded from heat resisting material.

14.2. The lamps shall be provided with suitable resistors.

14.3. Lamps and lenses shall be interchangeable and easily replaceable from the front of the panel. Tools, if required for replacing the bulbs and lenses shall also be included in the scope of the supply.

14.4. The indicating lamps with resistors shall withstand 120% of rated voltage on a continuous basis.

15. POSITION INDICATORS (if Applicable)

15.1. Position indicators of "SEMAPHORE" type shall be provided when specified as part of the mimic diagrams on panels for indicating the position of circuit breakers, isolating/earthing switches etc. The indicator shall be suitable for semi-flush mounting with only the front disc projecting out and with terminal connection from the rear.

15.2. Position indicator shall be suitable for DC Voltage as specified. When the supervised object is in the closed position, the pointer of the indicator shall take up a position in line with the mimic bus bars, and at right angles to them when the object is in the open position. When the supply failure to the indicator occurs, the pointer shall take up an intermediate position to indicate the supply failure.

15.3. The rating of the indicator shall not exceed 2.5 W.

15.4. The position indicators shall withstand 120% of rated voltage on a continuous basis.

16. SYNCHRONISING EQUIPMENT

16.1. For sub-station equipped with sub-station Automation system, the requirement of synchronisation is specified in Chapter Sub-station Automation System and the same shall prevail. For other sub-station which is not equipped with sub-station automation system following shall be applicable as per requirement.

16.2. The synchronising instruments shall be mounted either on a synchronising trolley or on a synchronising panel. The panel/ trolley shall be equipped with double analog voltmeters and double analog frequency meters, synchroscope and lamps fully wired. The size of voltmeters and frequency meters provided in the synchronising panel shall not be less than 144 X 144 sq. mm. Suitable auxiliary voltage transformers wherever necessary shall also be provided for synchronising condition. In case the synchroscope is not continuously rated, a synchroscope cut-off switch shall be provided and an indicating lamp to indicate that the synchroscope is energised, shall also be provided.

16.3. Synchronising check relay with necessary ancillary equipment's shall be provided which shall permit breakers to close after checking the requirements of synchronising of incoming and running supply. The phase angle setting shall not exceed 35 degree and have voltage difference setting not exceeding 10%. This relay shall have a responsetime of less than 200 milliseconds when the two system conditions are met within present limits and with the timer disconnected. The relay shall have a frequency difference setting not exceeding 0.45% at rated value and at the minimum time setting. A guard relay shall be provided to prevent the closing attempt by means of synchronising check relay when control switch is kept in closed position long before the two systems are in synchronism

16.4. The synchronising panel shall be draw out and swing type which can be swivelled in left and right direction. The synchronising panel shall be placed along with control panels and the number of synchronising panel shall be as indicated in BPS. The incoming and running bus wires of VT secondary shall be connected and run as bus wires in the control panels and will be extended to synchronising panel for synchronisation of circuit breakers. The selector switch provided for each circuit breaker in respective control panels shall be lockable type with a common key so that only one selector switch is kept in synchronising mode at a time.

16.5. Alternatively, the trolley shall be of mobile type with four rubber-padding wheels capable of rotating in 360 degree around the vertical axis. Suitable bumpers with rubber padding shall be provided all around the trolley to prevent any accidental damage to any panel in the control room while the trolley is in movement. The trolley shall have two meter long flexible cord fully wired to the instruments and terminated in a plug in order to facilitate connecting the trolley to any of the panels. The receptacle to accept the plug shall be provided on the panel.

16.6. At existing sub-stations, the synchronising scheme shall be engineered to be compatible with the existing synchronising scheme and synchronising socket/switch on the panel. In substations, where synchronising panels are available, the bidder shall carry out the shifting of the above panels, if required, to facilitate the extension of control panel placement.

17. RELAYS

17.1. All relays shall conform to the requirements of IEC- 255/IEC 61000 or other applicable standards. Relays shall be suitable for flush or semi-flush mounting on the front with connections from the rear.

17.2. All protective relays shall be of numerical type and communication protocol shall be as per IEC 61850. **Protective relays shall also fulfil the requirements specified for Protection IEDs in Chapter-Substation automation system**

17.3. All protective relays shall be in draw out or plug-in type/modular cases with proper testing facilities. Necessary test plugs/test handles shall be supplied loose and shall be included in contractor's scope of supply.

17.4. All AC operated relays shall be suitable for operation at 50 Hz. AC Voltage operated relays shall be suitable for 110 Volts VT secondary and current operated relays for 1 amp CT secondary. All DC operated relays and timers shall be designed for the DC voltage specified, and shall operate satisfactorily between 80% and 110% of rated voltage. Voltage operated relays shall have adequate thermal capacity for continuous operation.

17.5. The protective relays shall be suitable for efficient and reliable operation of the protection scheme described in the specification. Necessary auxiliary relays and timers required for interlocking schemes for multiplying of contacts suiting contact duties of protective relays and monitoring of control supplies and circuits, lockout relay monitoring circuits etc. also required for the complete protection schemes described in the specification shall be provided. All protective relays shall be provided with at least two pairs of potential free isolated output contacts. Auxiliary relays and timers shall have pairs of contacts as required to complete the scheme; contacts shall be silver faced with spring action. Relay case shall have adequate number of terminals for making potential free external connections to the relay coils and contacts, including spare contacts.

17.6. Timers shall be of solid state/numerical type. Time delay in terms of milliseconds obtained by the external capacitor resistor combination is not preferred and shall be avoided.

17.7. No control relay, which shall trip the power circuit breaker when the relay is de-energised, shall be employed in the circuits.

17.8 Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and maintenance.

17.9 Auxiliary seal-in-units provided on the protective relays shall preferably be of shunt reinforcement type. If series relays are used the following shall be strictly ensured:

a) The operating time of the series seal-in-unit shall be sufficiently shorter than that of the trip coil or trip relay in series with which it operates to ensure definite operation of the flag indicator of the relay.
b) Seal-in-unit shall obtain adequate current for operation when one or more relays operate simultaneously.
c) Impedance of the seal-in-unit shall be small enough to permit satisfactory operation of the trip coil on trip relays when the D.C. Supply Voltage is minimum.
d) Trip-circuit seal-in is required for all trip outputs, irrespective of the magnitude of the interrupted current. The trip-circuit seal-in logic shall not only seal-in the trip output(s),but also the relevant initiation signals to other scheme functions, (e.g. initiate signals to the circuit-breaker failure function, reclosing function etc.), and the alarm output signals
e) Two methods of seal-in are required, one based on the measurement of AC current, catering for those circumstances for which the interrupted current is above a set threshold, and one based on a fixed time duration, catering for those circumstances for which the interrupted current is small (below the set threshold).
f) For the current seal-in method, the seal-in shall be maintained until the circuit-breaker opens, at which time the seal-in shall reset and the seal-in method shall not now revert to the fixed time duration method. For this seal-in method, the seal-in shall be maintained for the set time duration. For the line protection schemes, this time duration shall be independently settable for single- and three-pole tripping.

(g) Seal-in by way of current or by way of the fixed duration timer shall occur irrespective of whether the trip command originates from within the main protection device itself (from any of the internal protection functions), or from an external device with its trip output routed through the main protection device for tripping. Trip-circuit seal-in shall not take place under sub-harmonic conditions (e.g. reactor ring down).

17.10. The setting ranges of the relays offered, if different from the ones specified shall also be acceptable if they meet the functional requirements.

17.11. Any alternative/additional protections or relays considered necessary for providing complete effective and reliable protection shall also be offered separately. The acceptance of this alternative/ additional equipment shall lie with the Employer.

17.12. All relays and their drawings shall have phase indications as R-Red, Y-yellow, B-blue.

17.13. For numerical relays, the scope shall include the following:

a) Necessary software and hardware to up/down load the data to/from the relay from/to the personal computer installed in the substation. However, the supply of PC is not covered under this clause.

b) The relay shall have suitable communication facility for future connectivity to SCADA. The relay shall be capable of supporting IEC 61850 protocol.

c) In case of line protection and transformer/reactor protection, the features like fault recorder and event logging function as available including available as optional feature in these relays shall be supplied and activated at no extra cost to the owner. Also necessary software/ hardware for automatic uploading to station HMI/DR work station (as applicable) shall be supplied. It is to be clearly understood that these shall be in addition to Fault recorder function as specified at clause no. 28.

18. TRANSMISSION LINE PROTECTION

18.1. All relays shall be suitable for series compensated line.

18.2. The line protection relays are required to protect the line and clear the faults on line within shortest possible time with reliability, selectivity and full sensitivity to all type of faults on lines. The general concept is to have two main protections having equal performance requirement specially in respect of time as called Main-I and Main-II for 400KV and 220KV transmission lines and Main and back up protection for 132 KV transmission lines.

18.3. The Transmission system for which the protection equipment are required is indicated in Chapter – PSR.

18.4. The maximum fault current could be as high as 63kA but the minimum fault current could be as low as 20% of rated current of CT secondary. The starting & measuring relays characteristics should be satisfactory under these extremely varying conditions.

18.5. The protective relays shall be suitable for use with capacitor voltage transformers having non-electronic damping and transient response as per IEC.

18.6. Fault Recorder, Distance to fault Locator and Over voltage relay stage-1/2) functions if offered as an integral part of line protection relays, shall be acceptable provided these meet the technical requirements as specified in the respective clauses.

18.7. Auto reclose relay function if offered as an integral part of line distance protection relay, shall be acceptable for **132kV & below lines** only provided the auto reclose relay feature meets the technical requirements as specified in the respective clause.

18.8. The following protections shall be provided for each of the Transmission lines:

For 400kV & 220kV Lines

Main-I: Distance protection scheme**.**

Main-II: Distance protection scheme

Main-I & Main-II relay shall be of different make &model. Same make relay shall be acceptable only if they are of different hardware & manufacturing platform.

If specified in Chapter-PSR, Main-I and / or Main-II relay shall be provided as Line differential protection relay with built in distance function. Further, matching Line differential protection relays for remote ends shall be provided as per Bid Price Schedule (BPS).

For 132KV

Main: Distance protection scheme
Back up: Directional Over Current and Earth fault Protection
The detailed description of line protections is given here under.

18.9. Main-I and Main-II Distance Protection scheme:

a) shall have continuous self-monitoring and diagnostic feature
b) shall be non-switched type with separate measurements for all phase to phase and phase to ground faults
c) shall have stepped time-distance characteristics and independent **three forward zones and one reverse/offset** zone
d) shall have mho or quadrilateral or other suitably shaped characteristics for **all zones**.
e) shall have following maximum operating time (including trip relay time, if any) under given set of conditions and with CVT being used on line (with all filters included)

(i) for 400 KV & 220 KV lines:		
For Source to Impedance ratio:	**4**	**15**
Relay setting (Ohms)	(10 or 20) and 2	2
Fault Locations (as % of relay setting)	50	50
Fault resistance (Ohms)	0	0
Maximum operating time (Milliseconds)	40 for all faults	45 for 3 ph. Faults & 60 for all other faults
(ii) for 132 KV lines:		
A relaxation of 5 ms in above timings is allowed for 132 KV lines.		

f) The relay shall have an adjustable characteristics angle setting range of 30-85 degree or shall have independent resistance(R) and reactance (X) setting.
g) shall have two independent continuously variable time setting range of 0-3 seconds for zone-2 and 0-5 seconds for zone-3/reverse zone.
h) shall have resetting time of less than 55 milli-seconds (including the resetting time of trip relays)
i) shall have variable residual compensation for each zone
j) shall have memory techniques with defined characteristics in all three phases to ensure correct operation during close-up 3 phase faults and other adverse conditions and shall operate instantaneously when cir- cuit breaker is closed to zero-volt 3 phase fault
k) shall have weak end in-feed feature
l) shall be suitable for single & three phase tripping
m) shall have a continuous current rating of two times of rated current. The voltage circuit shall be capable of operation at 1.2 times rated voltage. The relay shall also be capable of carrying a high short time current of 70 times rated current without damage for a period of 1 sec.
n) shall be provided with necessary self reset type trip duty contacts for completion of the scheme (Minimum number of these trip duty contacts shall be four per phase) either through built in or through separate high speed trip relays. Making capacity of these trip contacts shall be 30 amp for 0.2 seconds with an inductive load of L/R > 10 milli seconds. If separate high speed trip relays are used , the operating time of the same shall not be more than 10 milliseconds
o) shall be suitable for use in permissive under reach/ over reach/blocking communication mode
p) shall have suitable number of potential free contacts for Carrier aided Tripping, Auto reclosing, CB failure, Disturbance/Fault recorder & Data acquisition system
q) include power swing blocking and out-of-step protection which shall
    - have suitable setting range to encircle the distance protection described above
    - block tripping of distance function zones during power swing conditions
    - release blocking in the event of actual fault
    - release tripping on detection of out-of-step power swing condition
    - Alternatively standalone relay for out of step protection shall also be acceptable, if the same is not part of main protection relays.
r) include fuse failure protection which shall monitor all the three fuses of C.V.T. and associated cable against open circuit
    - inhibit trip circuits on operation and initiate annunciation
    - have an operating time less than 7 milliseconds
    - remain inoperative for system earth faults

s) include a directional back up Inverse Definite Minimum Time (IDMT) earth fault relay with normal inverse characteristics as per IEC 60255-3 as a built in feature or as a separate unit for 400 KV and 220KV transmission lines.
t) Must have a current reversal guard feature.

u) Shall have Stub protection function with current setting minimum range of 1 to 3 pu with definite time delay setting minimum range of 0 to 100msec.
v) have feature of load encroachment blinder to safeguard the protection trip during heavy line loading condition.

18.10. **Line Differential Relay protection scheme (If applicable)**

The line current differential relay with built-in distance protection function shall be capable of being selected to differential function with back up distance function or shall activate back up distance automatically when the differential relay is out of service. The relay shall fulfil the requirement specified above at clause 18.9 for distance relay function.

Further, the line current differential function shall conform to the following main requirements:

i. The current differential shall be a unit system of protection.

ii. The line Current differential Protection shall comprise a well-proven high-speed phase segregated numerical current differential protection scheme, which shall be designed for the selective protection of the EHV network.

iii. The High speed numerical current differential protection shall be suitable to work through directly connected fiber optics and the relay shall have the requisite teleprotection communication capability.

iv. Shall have built-in signalling modules for communication with the remote end relay via direct optical fiber cables.

v. The contractor shall coordinate the requirements of the current differential relay with the communication system in order to ensure compatibility between the two.

vi. The relay shall incorporate inter-tripping, VT Supervision functions and heavy duty contacts for tripping of the feeder circuit breaker as well as provide all flagging, alarms etc.

vii. Shall have high-speed fault detection capability with typical relay operation time of less than **30** ms for 400kV/220kV line faults and less than 40 ms for 132kV & below.

viii. Shall have high sensitivity for all types of faults.

ix. Shall detect and clear faults along the whole length of the feeder within the specified operating time when the remote end breaker is open or there is a weak in feed.

x. Shall remain stable for fault on a parallel feeder under subsequent current reversal in the healthy feeder due to slow opening of one of the faulty feeder's circuit breakers.

xi. Shall not be affected by heavy load transfer, power swings, CT saturation, distorted primary currents and voltages, VT fuse failure, line charging currents external switching, arc or tower footing resistance, sudden power reversal, zero sequence mutual coupling, fault resistance and out of phase source at the two line terminals producing misleading apparent fault reactance, power frequency variations, collapse of voltage on the faulted phase(s), etc.

xii. Shall have features to clear close in faults at high speed in the event of failure of signalling channel.

xiii. Shall have features to test at one end all the functions associated with the protection, without the presence of personnel at the remote end.

xiv. Shall have features to block relay in case of signalling channel failure or remote relay out of service / block or setting mismatch or dc failure etc., to avoid inadvertent tripping and shall produce alarm during blocking.

xv. Shall have inter-tripping compliant with IEC60834-1 and IEC60834–2 respectively for signalling as appropriate.

xvi. The line differential device address shall be settable and shall be suitable to set for no. of feeders shown in SLD.

xvii. CT supervision / VT Supervision shall be configured to initiate alarm locally and to sub-station automation system or event recorder as per requirement.

xviii. Shall have single pole/three pole tripping feature.

xix. Shall have built-in SOTF logic feature.

xx. Shall have features to block auto-reclose internally or externally at local end and facility to send blocking signals to remote end relay internally (through FO communication channels) during SOTF trips.

xxi. Shall have facility to configure signal transferred between local and remote end relays in the internal event recorder and disturbance recorder.

xxii. Shall have configurable time delayed thermal protection element and back up earth fault protection element.

xxiii. Shall have following features:

- Satisfactory Performance of relay under CT saturation during through faults.
- Satisfactory Performance of relay under conditions of CT saturation for in zone faults.
- Satisfactory Performance of relay during transient (jitter) and permanent changes in signalling propagation delays.

xxiv. Shall include necessary Optical fibre cable & associated accessories for connection between the current differential relay panel and existing Fibre optic distribution panel (FODP).

18.11. **Back-up Directional Over Current and Earth fault protection scheme**

(a) shall have three over current and one earth fault element(s) which shall be either independent or composite unit(s)

(b) shall include necessary VT fuse failure relays for alarm purposes

(c) **over current elements** shall

- have IDMT characteristic (normal inverse as per IEC)
- have a variable setting range of 50-200% of rated current
- have a characteristic angle of 30/45 degree lead
- include hand reset flag indicators or LEDs

(d) **earth fault element** shall

- have IDMT characteristic (normal inverse as per IEC)
- have a variable setting range of 20-80% of rated current
- have a characteristic angle of 45/60 degree lag
- include hand reset flag indicators or LEDs
- include necessary separate interposing voltage transformers or have internal feature in the relay for open delta voltage to the relay

18.12. **LINE OVER VOLTAGE PROTECTION RELAY** shall

(a) monitor all three phases

(b) have two independent stages

(c) **be either a standalone relay for both stage-I & II or as built in function of Main-I & Main-II distance relay for both stage-I & II.**

(d) have an adjustable setting range of 100-170% of rated voltage **with a setting least count of 0.1V (Secondary volts) and** an adjustable time delay range of 1 to 60 seconds for the first stage.

(e) have an adjustable setting range of 100-170% of rated voltage with a time delay of 100-200 mill seconds for the second stage.

(f) be tuned to power frequency

(g) provided with separate operation indicators (flag target) and **signal** for each stage relays **with phase indication for event logging**.

(h) have a drop-off to pick-up ratio greater than **97%**

18.13. All trip relays used in transmission line protection scheme shall be of self/electrical reset type depending on application requirement.

19. **CIRCUIT BREAKER PROTECTION:**

This shall include following functions:

19.1. **Numerical AUTO RECLOSING** function shall

(a) have single phase reclosing facilities

(b) have a continuously variable single phase dead time range of 0.1-2 seconds

(c) have a continuously variable reclaim time range of 5-300 seconds

(d) Incorporate a two position selector switch, from which single phase auto-reclosure and non-auto reclosure mode can be selected. Alternatively, the mode of auto reclosing can be selected through **HMI of the relay or BCU & SAS**.

(e) be of single shot type

(f) have priority circuit for closing of both circuit breakers in case of one and half breaker arrangements to allow sequential closing of breakers

(g) However, Auto-reclose as in built function of bay controller unit (BCU) (if supplied) is also acceptable **provided the signal exchange for auto-reclose function from BCU to main Relays & vice-versa is achieved through hardwiring**.

19.2. **LOCAL BREAKER BACK-UP (LBB) PROTECTION SCHEME** shall

(a) be triple pole type

(b) have an operating time of less than 15 milli seconds

(c) have a resetting time of less than 15 milli seconds

(d) have three over current elements

(e) be arranged to get individual initiation from the corresponding phase of main protections of line for each over current element. However, common three phase initiation is acceptable for other protections and transformer /reactor equipment protections

(f) have a setting range of 10-80% of rated current

(g) have a continuous thermal withstand two times rated current irrespective of the setting

(h) have a timer with continuously adjustable setting range of 0.1- 1 seconds

(i) have necessary auxiliary relays to make a comprehensive scheme

(j) Shall have re-trip feature for tripping its own CB after initiation with a set time delay.

(k) be acceptable as Built-in protection function of distributed bus bar protection scheme only; however in that case separate LBB relay shall be provided for tie bays.

(l) be similar relays for complete scope of work as per specification **(if provided as standalone relay unit).**

20. REACTOR PROTECTION

20.1. **Differential Protection Relay shall**

(a) be triple pole type

(b) have operation time less than 25 milli-seconds at 5 times setting

(c) be tuned to system frequency

(d) have current setting range of 10 to 40% of 1 Amp. or a suitable voltage setting range

(e) be high impedance / biased differential type

(f) be stable for all external faults, CT saturation.

20.2. **Restricted Earth Fault Protection Relay** shall

(a) be single pole type

(b) be of current/voltage operated high impedance type

(c) have a current setting of **05**-40% of 1 Amp./have a suitable voltage setting range

(d) be tuned to system frequency

(e) have a suitable non-linear resistor to limit the peak voltage to 1000 Volts

(f) Separate relay shall be provided for 1-phase spare reactor unit (if envisaged).

20.3. **Back up impedance protection Relay** shall

(a) be triple pole type, with faulty phase identification/ indication

(b) be single step polarised 'mho' distance/ impedance relay suitable for measuring phase to ground and phase to phase faults

(c) have adequate ohmic setting range to cover at least 60% of the impedance of the reactor and shall be continuously variable

(d) have an adjustable characteristic angle of 30-80 degree

(e) have a definite time delay relay with a continuously adjustable setting range of 0.2-2.0 seconds

(f) include VT failure relay which shall block the tripping during VT fuse failure condition

(g) have Back-up over current and earth fault protection as built in function

20.4. Further, Reactor auxiliary protections contacts (Buchholz, PRV, Oil Temperature, Winding Temperature etc.) can be wired suitably in above protections or provide separate Flag relays/Auxiliary relays as per scheme requirements. **Further reactor protections shall be grouped such that Differential protection, Buchholz-I trip and Winding temperature trip are on DC-A while REF protection, Back-up Impedance protection, PRD-I and Oil temperature trip are on DC-B. In case multiple trip contacts for Buchholz relay / PRD relays are available, then their contacts shall be wired to both Group of Protection.**

21. TRANSFORMER PROTECTION

21.1. **Transformer differential protection** scheme shall

(a) be triple pole type, with faulty phase identification/ indication

(b) have an operating time not greater than 30 milli seconds at 5 times the rated current

(c) have three instantaneous high set over-current units

(d) **be bias differential type having** an adjustable bias setting range of 10-50%

(e) be suitable for **04 nos. of 3-ph CT input** with rated **CT secondary** current of 1 Amp.

(f) have second harmonic or other inrush proof features and also should be stable under normal over fluxing conditions. Magnetising inrush proof feature shall not be achieved through any intentional time delay e.g. use of timers to block relay operation or using disc operated relays

(g) have an operating current setting of 15% or less

(h) include necessary separate interposing current transformers for angle and ratio correction or have internal feature in the relay to take care of the angle & ratio correction

(i) have a fault recording feature to record graphic form of instantaneous values of following analogue channels during faults and disturbances for the pre fault and post fault period:

Current in all three windings in nine analogue channels in case of 400kV class or 6 analogue channels for lower voltage transformers and Voltage in one channel

The disturbance recorder **function built in the Differential protection IED** shall have the facility to record the following external digital channel signals associated with transformer **which shall be wired to differential relay** apart from the digital signals pertaining to differential relay:

1. REF protection operated
2. HV Breaker status (Main & tie/transfer both separately)
3. IV Breaker status (Main & tie/transfer both separately)
4. **Bucholz / OLTC/ WTI/ OTI alarm**
5. **Bucholz / PRD / SPR/ Trip**
6. **Group-A, Group-B lock-out relay trip**

Necessary hardware and software, for automatic up-loading the data captured by disturbance recorder to the personal computer (DR Work Station) available in the substation, shall be included in the scope.

21.2. **Over Fluxing Protection Relays** shall

(a) operate on the principle of Voltage to frequency ratio and shall be phase to phase connected

(b) have inverse time characteristics, matching with transformer over fluxing withstand capability curve

(c) provide an independent 'alarm' with the time delay continuously adjustable between 0.1 to 6.0 seconds at values of 'v/f' between 100% to 130% of rated values

(d) tripping time shall be governed by 'v/f' Versus time characteristics of the relay

(e) have a set of characteristics for Various time multiplier settings. The maximum operating time of the relay shall not exceed 3 seconds and 1.5 seconds at 'v/f' values of 1.4 and 1.5 times, the rated values, respectively.

(f) have an accuracy of operating time, better than ±10%

(g) have a resetting ratio of **97 %** or better.

21.3. **Restricted Earth Fault Protection** shall

(a) be single pole type

(b) be of current/voltage operated type

(c) have a current setting range **of 5-40%** of 1 Amp./ have a suitable voltage setting range

(d) be tuned to the system frequency

(e) be phase segregated type for 1-ph transformer units

(f) Separate relay shall be provided for 1-phase spare transformer unit (if envisaged).

21.4. **Back-up Over Current and Earth fault protection scheme with high set feature**

(a) Shall have three over current and one earth fault element(s) which shall be either independent or composite unit(s).

(b) The scheme shall include necessary VT fuse failure relays for alarm purposes.

(c) Over current relay shall

- have directional IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting and have a variable setting range of 50-200% of rated current
- have low transient, over reach high set instantaneous unit of continuously variable setting range 500-2000 % of rated current

- have a characteristic angle of 30/45 degree lead
- include hand reset flag indicators or LEDs.

(d) Earth fault relay shall

- have directional IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting and have a variable setting range of 20-80% of rated current
- have low transient, over reach high set instantaneous unit of continuously variable setting range 200-800 % of rated current
- have a characteristic angle of 45/60 degree lag
- include hand reset flag indicators or LEDs
- include necessary separate interposing voltage transformers or have internal feature in the relay for open delta voltage to the relay

21.5. **Transformer Overload Protection Relay** shall

(a) be of single pole type

(b) be of definite time over-current type

(c) have one set of over-current relay element, with continuously adjustable setting range of 50-200% of rated current

(d) have one adjustable time delay relay for alarm having setting range of 1 to 10.0 seconds, continuously.

(e) have a drop-off/pick-up ratio greater **than 95%.**

21.6. **Transformer Neutral Current Protection relay** (for 1-Phase transformer bank neutral) shall

(a) have directional IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting and have a variable setting range of 20-80% of rated current.

21.7. Further, Transformer auxiliary protections contacts (Buchholz, PRD, **SPRD**, Oil Temperature, Winding Temperature, OLTC Buchholz etc. can be wired suitably in above protections or provide separate Flag relays/Auxiliary relays as per scheme requirements. **Further, transformer protections shall be grouped such that Differential trip, Buchholz-I trip, Oil temperature alarm and Winding temperature trip are on DC source-A while REF trip, Buchholz alarm, PRD-I trip, winding temperature alarm and Oil temperature trip are on DC source-B. In case multiple trip contacts for Buchholz relay / PRD relays are available, then their contacts shall be wired to both Group of Protection.**

22. TEE DIFFERENTIAL PROTECTION RELAYS (If Applicable)

22.1. **TEE-1 Differential (Bias) protection relay** shall

(a) be triple pole type

(b) have an operating time less than 30 milliseconds at 5 times the rated current

(c) have three instantaneous high set over current units

(d) have an adjustable bias setting range of 20-50%

(e) have an operating current setting of 15% of 1 Amp or less

22.2. **TEE-2 Differential (High Impedance) Protection relay** shall

(a) be triple pole type

(b) have operating time less than 25 milliseconds at 5 times setting

(c) be tuned to system frequency

(d) have current setting range of 20 to 80% of 1 Amp

(e) be voltage operated, high impedance type

(f) be stable for all external faults

(g) be provided with suitable non linear resistors across the relay to limit the peak voltage to 1000 volts

23. **TRIP CIRCUIT SUPERVISION RELAY**

(a) The relay shall be capable of monitoring the healthiness of each 'phase' trip-coil and associated circuit of circuit breaker during 'ON' and 'OFF' conditions.

(b) The relay shall have adequate contacts for providing connection to alarm and event logging.

(c) The relay shall have time delay on drop-off of not less than 200 milli seconds and be provided with operation indications for each phase

24. **TRIPPING RELAY**

High Speed Tripping Relay shall

(a) be instantaneous (operating time not to exceed 10 milli-seconds).

(b) reset within 20 milli seconds

(c) be D.C. operated

(d) have adequate contacts to meet the requirement of scheme, other functions like auto-reclose relay, LBB relay as well as cater to associated equipment like event logger (SAS), Disturbance recorder, fault Locator, etc.

(e) be provided with operation indicators for each element/coil.

25. **DC SUPPLY SUPERIVISION RELAY**

(a) The relay shall be capable of monitoring the failure of D.C. supply to which, it is connected.

(b) It shall have adequate potential free contacts to meet the scheme requirement.

(c) The relay shall have a 'time delay on drop-off' of not less than 100 milli seconds and be provided with operation indicator/flag.

26. BUS BAR PROTECTION

26.1. Redundant (1+1) numerical **low impedance biased differential** Bus Bar protection scheme for each Main bus (Bus1 / Bus2) & Transfer Bus (as applicable) for 400kV shall be provided**.** The scheme shall be engineered so as to ensure that operation of any one out of two schemes connected to faulty bus shall result in tripping of the same.

26.2. Single bus bar protection scheme shall be provided for each main bus and transfer bus (as applicable) for 220KV and 132 KV voltage levels.

26.3. Each Bus Bar protection scheme shall

(a) have maximum operating time up to trip impulse to trip relay of 25 milli seconds at 5 times setting value for all types of faults.

(b) operate selectively for each bus bar

(c) give hundred percent security up to 63 KA fault level for 400KV and 220KV and 31.5 KA for 132 KV system.

(d) incorporate continuous supervision for CT secondary against any possible open circuit and if it occurs, shall render the relevant zone of protection inoperative and initiate an alarm.

(e) not give false operation during normal load flow in bus bars

(f) not cause tripping for the differential current below the load current of heaviest loaded feeder. Contractor shall submit application check for the same.

(g) be of phase segregated and triple pole type

(h) incorporate clear zone indication

(i) provide independent zones of protection (including transfer bus if any). If the bus section is provided then each side of bus section shall have separate set of bus bar protection schemes

(j) include protection 'IN/OUT' switch for each zone

(k) include individual high speed electrically reset tripping relays for each feeder. However, in case of distributed Bus bar protection, individual trip relay shall not be required if bay unit is having trip duty contacts for breaker tripping.

(l) be transient free in operation

(m) include continuous D.C. supplies supervision

(n) shall include necessary C.T. switching relays wherever C.T. switching is involved and have 'CT' selection incomplete alarm

(o) shall include trip relays, CT switching relays (if applicable), auxiliary CTs (if applicable) as well as additional power supply modules, input modules etc. as may be required to provide a Bus-bar protection scheme for the complete bus arrangement i.e. for all the bays or breakers including future bays as per the Single line diagram for new substations. However for extension of bus bar protection scheme in existing substations, scope shall be limited to the bay or breakers **covered in the scope of work**. Suitable panels (if required) to mount these are also included in the scope of the work.

(p) In case of distributed Bus bar Protection, the bay units for future bays may be installed in a separate panel and the same shall be located in switchyard panel room where bus bar protection panel shall be installed.

26.4. At existing substations, Bus-bar protection scheme with independent zones for each bus, will be available. All necessary co-ordination for 'AC' and 'DC' interconnections between existing schemes (Panels) and the bays proposed under the scope of this contract shall be fully covered by the bidder. Any auxiliary relay, trip relay, flag relay and multi tap auxiliary CTs (in case of biased differential protection) required to facilitate the operation of the bays covered under this contract shall be fully covered in the scope of the bidder.

26.5. The test terminal blocks (TTB) to be provided shall be fully enclosed with removable covers and made of moulded, non-inflammable plastic material with boxes and barriers moulded integrally. All terminals shall be clearly marked with identification numbers or letters to facilitate connection to external wiring. Terminal block shall have shorting, disconnecting and testing facilities for CT circuits.

27. WEATHER PROOF RELAY PANELS (For CT switching, If Applicable)

(a) This panel shall include necessary number of electrically reset relays each with at least eight contacts for isolator auxiliary contacts multiplication and for changing the CT and DC circuits to relevant zones of bus bar protection.

(b) The panel shall be sheet steel enclosed and shall be dust, weather and vermin proof. Sheet steel used shall be at least 2.0 mm thick and properly braced to prevent wobbling.

(c) The enclosures of the panel shall provide a degree of protection of not less than IP-55 (as per IEC-60529).

(d) The panel shall be of free standing floor mounting type or pedestal mounting type as per requirement.

(e) The panel shall be provided with double hinged doors with padlocking arrangement.

(f) All doors, removable covers and panels shall be gasketed all around with synthetic Neoprene/EPDM gaskets. However, XLPE gaskets can also be used for fixing protective glass doors. Ventilating louvers, if provided shall have screens and filters. The screens shall be made of either brass or GI wire mesh.

(g) Cable entries shall be from bottom. Suitable removable cable gland plate shall be provided on the cabinet for this purpose.

(h) All sheet steel work shall be degreased, pickled, phosphated and then applied with two coats of zinc chromates primer and two coats of finishing synthetic enamel paint, both inside and outside. The colour of the finishing paint shall be light grey in accordance with shade no.697 of IS: 5.

(i) Suitable heaters shall be mounted in the panel to prevent condensation. Heaters shall be controlled by thermostats so that the cubicle temperature does not exceed 30^{o}C. On-off switch and fuse shall be provided. Heater shall be suitable for 230V AC supply Voltage.

(j) The test terminal blocks (TTB) to be provided shall be fully enclosed with removable covers and made of moulded, non-inflammable plastic material with boxes and barriers moulded integrally. All terminals shall be clearly marked with identification numbers or letters to facilitate connection to external wiring. Terminal block shall have shorting, disconnecting and testing facilities for CT circuits.

28. **FAULT RECORDER**

28.1. The fault recorder shall be provided for transmission lines. The fault recorder as in-built feature of line distance relay is also acceptable provided the requirements of following clauses are met.

28.2. Fault recorder shall be microprocessor based and shall be used to record the graphic form of instantaneous values of voltage and current in all three phases, open delta voltage & neutral current, open or closed position of relay contacts and breakers during the system disturbances.

28.3. The Fault recorder shall consist of individual acquisition units, one for each feeder and an Evaluation unit which is common for the entire Substation. Whenever, more than one acquisition units are connected to an Evaluation unit, necessary hardware and software shall also be supplied for on line transfer of data from all acquisition units to Evaluation unit.

28.4. The acquisition unit is connected with evaluation unit being supplied as described in Chapter sub-station automation through bus conforming to IEC 61850. In case of extension sub-station which is equipped with Sub-station Automation System based on IEC 61850, one set of evaluation software shall be supplied and loaded in existing fault recorder evaluation unit. Automatic uploading of disturbance files from acquisition unit to evaluation unit shall be done through existing station bus only conforming to IEC 61850. Necessary configuration/updation including hardware if any shall be in the scope of the contractor.

28.5. In case of extension of existing substation(s) which are without sub-station automation system, one set of Evaluation unit shall be supplied for each substation where ever disturbance recorders are required **(as per Chapter-PSR)** to be supplied along with necessary evaluation software as specified above. The Evaluation unit shall consist of a desktop personal computer (including at least 17" TFT colour monitor, mouse and keyboard) and **A4 size colour** printer. The desktop PC shall have **I5** processor or better and having a clock speed **2.0** GHz or better. The hard disk capacity of PC shall not be less than **1000** GB and RAM capacity shall not be less than **4** GB.

28.6. The evaluation unit hardware, for substations having SAS, shall be as described in Chapter sub-station automation system.

28.7. Fault recorder shall have at least 8 analogue and 16 digital channels for each feeder.

28.8. Acquisition units shall acquire the Disturbance data for the pre fault and post fault period and transfer them to Evaluation unit automatically to store in the hard disk. The acquisition units shall be located in the protection panels of the respective feeders.

28.9. The acquisition unit shall be suitable for inputs from current transformers with 1A rated secondary and capacitive voltage transformers with 63.5V (phase to neutral voltage) rated secondary. Any device required for processing of input signals in order to make the signals compatible to the Fault recorder equipment shall form an integral part of it. However, such processing of input signals shall in no way distort its waveform.

28.10. The equipment shall be carefully screened, shielded, earthed and protected as may be required for its safe functioning. Also, the Fault recorder shall have stable software, reliable hardware, simplicity of maintenance and immunity from the effects of the hostile environment of EHV switchyard which are prone to various interference signals typically from large switching transients.

28.11. Evaluation software shall be provided for the analysis and evaluation of the recorded data made available in the PC under WINDOWS environment. The Software features shall include repositioning of analog and digital signals, selection and amplification of time and amplitude scales of each analogue and digital channel, calculation of MAX/MIN frequency, phase difference values, recording of MAX/MIN values etc. of analogue channel, group of signal to be drawn on the same axis etc, listing and numbering of all analogue and digital channels and current, voltage, frequency and phase difference values at the time of fault/tripping. Also, the software should be capable of carrying out Fourier /Harmonic analysis of the current and voltage wave forms. The Disturbance records shall also be available in COMTRADE format (IEEE standard- Common Format for Transient data Exchange for Power System)

28.12. The Evaluation unit shall be connected to the color printer to obtain the graphic form of disturbances whenever desired by the operator.

28.13. Fault recorder acquisition units shall be suitable to operate from 220V DC or 110V DC as available at sub-station. Evaluation unit along with the printer shall normally be connected to 230V, single phase AC supply. In case of failure of AC supply, Evaluation unit and printer shall be switched automatically to the station DC through Inverter of adequate capacity which shall form a part of Fault recorder system. The inverter of adequate capacity shall be provided to cater the requirement specified in Chapter - sub-station automation and DR evaluation unit.

28.14. The acquisition unit shall have the following features

(a) Facility shall exist to alarm operator in case of any internal faults in the acquisition units such as power supply fail, processor / memory fail etc and same shall be wired to annunciation system**/SAS**.

(b) The frequency response shall be 5 Hz on lower side and 250 Hz or better on upper side.

(c) Scan rate shall be 1000 Hz/channel or better.

(d) Pre-fault time shall not be less than **500** milliseconds and the post fault time shall not be less than 2 seconds (adjustable). If another system fault occurs during one post-fault run time, the recorder shall also be able to record the same. **However, the total memory of acquisition unit shall not be less than 5.0 seconds.**

(e) The open delta voltage and neutral current shall be derived either through software or externally by providing necessary auxiliary transformers.

(f) The acquisition unit for line fault recorder shall be typically used to record **at least** the following digital channels :

1 Main CB R phase open

2 Main CB Y phase open

3 Main CB B phase open

4 Tie/TBC CB R phase open

5 Tie/TBC CB Y phase open

6 Tie/TBC CB B phase open

7 Main-1 carrier received

8 Main-1 protection operated

9 Main/Tie /TBC Auto reclosed operated

10 Over Voltage -Stage-1 /2 operated

11 Reactor / Stub/TEE-1/2/UF protection operated

12 Direct Trip received

13 Main-2 carrier received

14 Main- 2/ Back Up protection operated

15 Bus bar protection operated

16 LBB operated of main /tie/TBC circuit breaker

(g) In case the Fault recorder is in-built part of line distance protection, above digital channels may be interfaced either externally or internally.

(h) The sequence of digital channels shall be as per above list and which shall be ensured by the contractor. Digital channels shall be named suitably for easy identification of signals in the fault recordings.

(i) Any digital signal can be programmed to act as trigger for the acquisition unit. Analog channels should have programmable threshold levels for triggers and selection for over or under levels should be possible.

28.15. The **colour laser** printer **(A4 size)** shall be provided which shall be compatible with the desktop PC and shall use Plain paper. The print out shall contain the Feeder identity, Date and time (in hour, minute and second up to 100th of a second), identity of trigger source and Graphic form of analogue and digital signals of all the channels.

28.16. Each Fault recorder shall have its own time generator and the clock of the time generator shall be such that the drift is limited to $\pm$0.5 seconds/day, if allowed to run without synchronisation. Further, Fault recorder shall have facility to synchronise its time generator from Time Synchronisation Equipment having output of following types :

- Voltage signal: (0-5V continuously settable, with 50m Sec. minimum pulse duration)
- Potential free contact (Minimum pulse duration of 50 m Sec.)
- IRIG-B
- RS232C
- **SNTP**

The recorder shall give annunciation in case of absence of synchronising within a specified time.

28.17. Substations where Time Synchronisation Equipment is not available, time generator of any one of the Fault recorders can be taken as master and time generators of other Fault recorders and Event loggers in that station shall be synchronised to follow the master.

29. **DISTANCE TO FAULT LOCATOR** shall

a. be electronic or microprocessor based type

b. be 'On-line' type

c. be suitable for breaker operating time of 2 cycles

d. have built-in display unit

e. the display shall be directly in percent of line length or kilometres without requiring any further calculations

f. have an accuracy of 3% or better for the typical conditions defined for operating timings measurement of distance relays

g. The above accuracy should not be impaired under the following conditions:

- presence of remote end infeed
- predominant D.C. component in fault current
- high fault arc resistance
- severe CVT transients

h. shall have mutual zero sequence compensation unit if fault locator is to be used on double circuit transmission line

i. built in feature of line distance relay is acceptable provided the requirements of above clauses are met.

30. **DISTANCE TO FAULT LOCATOR-Travelling Wave type (TWFL):**

Distance to Fault locator, based on Traveling wave detection method, shall

a. be microprocessor based, On-line type

b. have programmable triggering thresholds

c. be suitable for breaker operating time of minimum 2 cycles

d. consist of acquisition unit and one central unit

e. provide fault location reading directly in kilo-meter without requiring any further calculations

f. have fault location accuracy of + 150 Meter or better with a least count of atleast 50 meter for fault locator readings

g. The above accuracy should not be affected by followings:

- Line length
- Presence of remote end in-feed
- Series compensation
- Non-uniform line (having Cable & Over head line both)
- Mutual coupling
- Transposition of line
- Fault resistance
- Severe CVT transients

h. Acquisition units shall:

i. be either standalone for each line or with the capability to cater to a number of lines emanating from a substation. Incase more than one lines are to be accommodated in one acquisition unit then suitable coupler unit/measuring unit shall be provided in individual line bay C&R panels and only secondary wiring shall be brought to common acquisition unit. While offering this option, bidders are advised to take care of maximum distance between Acquisition unit & line bays C&R panels. In the BPS, total no. of line bays envisaged for Travelling Wave type Fault Locators is mentioned for further assessment by the bidder for no. of Acquisition units required for total functional requirements based on equipment design.

ii. include all required accessories (like couplers, cables, connectors etc) to connect to the secondary wiring of the Instrument transformers (in C&R panels) for detection of traveling wave

iii. have built-in backlit display unit and keypad

iv. have the facility to locally download the data in case of communication failure

v. have minimum 02 nos. binary input per line for line protection trip input. Binary input shall be rated for 220V DC and it shall be possible to set the de-bounce time of the binary input.

vi. have minimum **1GB** of storage space

vii. have facility to transmit the fault record to the Central unit by dialing mode, IEC60870-5-103 or IEC60870-5-104 or TCP/IP net protocol etc. Scope shall include dialup modem, if required with each Acquisition unit.

i. include required GPS time synchronizing units for each substation (internal or external to Acquisition unit)

j. Central data processing unit shall:

i. Consist of a desktop personal computer (including at least 17" TFT color monitor, mouse and keyboard), colour laser jet multi-function printer (A4 size), LAN switches (as required), all special cables and other required accessories. The desktop PC shall have Intel Dual core processor or better. The hard disk capacity of PC shall not be less than 1000 GB and RAM capacity shall not be less than
4 GB.

ii. have all necessary hardware & software for data download from Acquisition units, storage, processing, device (acquisition unit) creation and configuration, and comprehensive viewer for manual analysis of waveform. It will also have diagnostic feature to check the healthiness of connected devices & communication link.

iii. calculate & report the fault location based on the traveling wave data acquired from acquisition units of both end of the line. However, Central data processing unit shall have the facility to calculate the fault location even with only one end acquisition unit data of the line.

iv. be able to communicate to the Master station (Control centre) through IEC60870-5-104 net protocol. Alternate Standard protocol shall also be acceptable subject to fulfilling the functional requirements.

v. be located at local or any remote end based on the availability of communication link. End to end communication link shall be provided. However Scope shall also include a dialup modem with central data processing unit.

k. In cases, Central data processing unit of Travelling wave fault locator is existing at a location the Acquisition units under present scope can be integrated with the existing Central data processing unit (Make & Model of existing unit should be mentioned in Chapter-PSR) by required augmentation (configuration and up gradation of data base including supply of any additional hardware / software etc.). Alternatively, bidder may offer separate Central data processing unit & associated hardware
& software as may be required under the head of augmentation of Central data processing unit.

l. Include required no. of panels to house the offered equipments at various substations & central location. Acquisition units can also be mounted in respective line protection panels.

m. TWFL as built-in feature of Standalone fault recorder or Line Protection IED shall also be acceptable subject to meeting the functional requirement specified.

n. Type test (EMI/EMC) and additional functional test for accuracy shall be submitted for TWFL for review and approval.

31. TIME SYNCHRONISATION EQUPMENT

31.1. The Time synchronisation equipment shall receive the co-ordinated Universal Time (UTC) transmitted through Geo Positioning Satellite System (GPS) and synchronise equipments to the Nepali Standard Time in a substation.

31.2. Time synchronisation equipment shall include antenna, all special cables and processing equipment etc.

31.3. It shall be compatible for synchronisation of Event Loggers, Disturbance recorders and SCADA at a substation through individual port or through Ethernet realised through optic fibre bus.

31.4. Equipment shall operate up to the ambient temperature of 50 degree centigrade and 80% humidity.

31.5. The synchronisation equipment shall have 2 micro-second accuracy. Equipment shall give real time corresponding to IST (taking into consideration all factors like voltage, & temperature variations, propagation & processing delays etc).

32.6. Equipment shall meet the requirement of IEC 60255 for storage & Operation.

31.7. The system shall be able to track the satellites to ensure no interruption of synchronisation signal.

31.8. The output signal from each port shall be programmable at site for either one hour, half hour, minute or second pulse, as per requirement.

31.9. The equipment offered shall have six (6) output ports. Various combinations of output ports shall be selected by the customer, during detailed engineering, from the following :

- Potential free contact (Minimum pulse duration of 50 milli Seconds.)
- IRIG-B
- RS232C
- SNTP Port
- **IEEE 1588 PTP (*Applicable only for Process bus automation station*)**

31.10. The equipment shall have a periodic time correction facility of one second periodicity.

31.11. Time synchronisation equipment shall be suitable to operate from 220V DC or 110V DC as available at Substation.

31.12. Equipment shall have real time digital display in hour, minute, second (24 hour mode) & have a separate time display unit to be mounted on the top of control panels/**SAS panel** having display size of approx. 100 mm height.

32. Bay Control Unit (BCU): BCU supplied shall meet the requirements mentioned under technical specification Chapter- Substation automation.

33. INTERFACE PANEL (If specified in BPS)

a) Interface panel is envisaged to minimize cabling/termination time during erection stage at site, minimize hindrance in protection panel and also ease of trouble shooting. This panel shall be installed in Switchyard panel room and one no. interface panel shall be provided for each feeder. Tie bay can be accommodated in the Interface unit of any one of the associated feeder.

b) All control wiring from switchyard except CTs & CVTs shall be terminated in the interface panel. CTs and CVTs wiring shall be directly connected to the relay panel as per scheme requirements.

c) All wiring from Interface panel to relay panels or other panels (Inter-panel wiring) in the switchyard panel room shall be factory fitted / terminated through Plug-in type termination arrangement. Plug-in type termination shall be heavy duty industrial grade with double locking latch or screw locking arrangement with IP65 protection.

d) Minimum one number spare Plug-in type connector duly terminated on each side per inter-panel wiring circuit shall be provided for future use.

34. MONITORING, CONTROL & PROTECTION FOR AUXILIARY TRANSFORMER

Suitable monitoring, control (operation of associated circuit breaker & isolator) and protection for LT auxiliary transformer, connected to tertiary winding of auto transformer for the purpose of auxiliary supply shall be provided by the contractor. Over current and open delta protection is required to be provided for the auxiliary transformer. These protection and control shall be also be acceptable as built in feature either in the bay controller to be provided for the auxiliary system or in the control & protection IEDs to be provided for autotransformer.

35. RELAY Test KIT

35.1. One relay test kit shall comprise of the following equipment as detailed here under

3 sets	Relay tools kits
2 nos.	Test plugs **for each type of** TTB
2 nos.	Test plugs for using with modular type relays (if applicable)

36. CONFIGURATION OF RELAY AND PROTECTION PANELS

The following is the general criteria for the selection of the equipments to be provided in each type of panel. However, contractor can optimise the requirement of panels by suitably clubbing the feeder protection and CB relay panels. It may be noted that Main-I and Main-II protections for line can not be provided in single panel. Similarly, Group-I & Group-II protections for transformer can not be provided in single panel.

I) LINE PROTECTION PANEL: The Line Protection panel for transmission lines shall consist of following protection features/schemes

Sl. No.	Description	400kV	220kV	132kV
1.	Main-1 protection scheme	1 Set	1 Set	1 Set
2.	Main-2 protection scheme	1 Set	1 Set	NIL*

3.	Over Voltage Protection Scheme	1 Set	NIL	NIL
4.	Fault Recorder	1 Set	1 Set	NIL
5.	Standalone Disturbance Recorder	NIL	NIL	NIL
6.	Distance to fault Locator	1 Set	1 Set	1 Set
7.	**Cut out for mounting of Distance to fault Locator (TWFL)**	**1 Set#**	NIL	NIL
8.	3 Phase Trip Relays	2 Nos.	2 Nos.	2 Nos.
9.	Flag relays, carrier receive relays, aux. Relays, timers etc as per scheme requirements	As required	As required	As required
10.	Under Voltage protection relay for isolator/earth switch **Interlock**	2 Nos	2 Nos	2 Nos
11.	Cut-out and wiring with TTB for energy meter	1 Set	1 Set	1 Set
12.	Directional Back up Over current and E/F protection scheme	NIL	NIL	1 Set
Note- 1)	*Back up –directional O/c & E/F protection is specified for 132kV system in place of Main-II			
Note- 2)	In a substation where 400kV and 220 KV lines are under the scope of the contract, bidder is required to give identical Main-1 and Main-2 distance protection schemes for all voltage levels.			
Note- 3)	Cut out & mounting arrangement provided for mounting of energy meter unit of 4" thickness			
Note-IV	# Cut out for mounting of Distance to Fault locator (Travelling wave type) shall be provided.			

II) TRANSFORMER PROTECTION PANEL: The protection panel for Auto transformer/Transformer shall consists of the following features/schemes:

Sl. No.	Description	HV side	MV/LV side
1.	Transformer Differential Protection scheme	1 Nos.	Nil
2.	Restricted Earth fault protection scheme	1 no.	1 no@
	@ Not applicable for auto-transformer		

3.	Directional back up O/C and E/F relay with non-directional high set feature	1 set	1 set
4.	Over Fluxing Protection scheme	1 no.	1 no.$
	$ Applicable only for 400/220kV Transformer		
5.	Overload protection scheme	1 nos.	NIL
6.	Three phase trip relays	2 nos.	2 nos.
7.	CVT selection relays as per scheme requirement	Lot	Lot
8.	Cut-out and wiring with TTB for energy meter	1 set	1 set
9.	Transformer Neutral Current relay for 1-Phase transformer bank	1 Set	
10.	**Tertiary side O/C and Open delta Voltage protection**	**1 Set**	
11.	Flag Relays/Aux. Relays for wiring Transformer auxiliary protection contacts such as Buchholz, Oil Temperature, Winding Temperature, PRV, SPRD, OLTC Buchholz etc. as per scheme requirements	As required	
Note- 1)	Tertiary side protections, over fluxing protection and overload protection can be clubbed in other transformer protection relay, however, over fluxing protection of HV and MV/LV side cannot be clubbed together. Further, tertiary side protection, if provided in auxiliary BCU, shall be excluded from this panel. This protection shall be applicable only for the transformer whose tertiary side is connected to LT transformer for station auxiliary supply.		
Note- 2)	Cut out & mounting arrangement provided for mounting of energy meter unit of 4" thickness		

III) REACTOR PROTECTION PANEL: The protection panel for Reactor shall consist of the following features/schemes:

Sl. No.	Description	Qty.
1.	Reactor Differential Protection scheme	1 no.
2.	Restricted Earth fault Protection scheme	1 no.
3.	Reactor back up impedance protection scheme	1 set
4.	Three phase trip relays	2 nos.

5.	CVT selection relay as per scheme requirement	Lot
6.	Flag Relays/Aux. Relays for wiring Reactor auxiliary protection contacts such as Buchholz, Oil Temperature, Winding Temperature, PRV, SPRD etc. as per scheme requirements	As required

IV) BREAKER RELAY PANEL: The breaker relay panel shall consist of the following:

Sl. No.	Description	With A/R	Without A/R
1.	Breaker failure Protection Scheme *	1 No.	1 No.
2.	DC supply Supervision relay	2 Nos.	2 Nos.
3.	Trip Circuit supervision relays#	6 Nos.	6 Nos.
4.	Auto-reclose scheme (if standalone)	1 Nos.	NIL
5.	Flag relays, aux relays, timers, trip relays as per scheme requirements	As required	As required
Note- 1)	# Trip supervision relays shall be 2 **or 6** numbers **as per no. of trip coils** for each 132KV Circuit breaker		
Note- 2)	**Equipment/relays to be provided under CB Relay Panel may be accommodated in the Protection Panels to be provided for Transmission Line/Transformer/Reactor as applicable.**		
Note- 3)	*** In case of bay extension in existing half diameter, breaker failure relay for main CB / Tie CB shall be supplied only if BFR built-in Bus Bar protection bay unit is not available or Tie CB standalone BFR relay is not available in the existing protection scheme.**		

V) <u>CONTROL PANEL</u>: Various types of control panels shall consist of the following:

a.	Ammeter	3 set	for each Line, BC, TBC Bus section, Bus Reactor and Transformer
b.	Ammeter with Selector switch	1 set	for each line reactor
c.	Wattmeter with transducer	1 set	for each line, transformer
d.	Varmeter with transducer	1 set	for each line, transformer, Bus reactor
e.	Varmeter with transducer	1 set	for each Line Reactor
f.	CB Control switch	1 no.	for each Circuit breaker
g.	Isolator Control switch	1 no.	for each isolator

h.	Semaphore	1 no.	for each earth switch
i.	Red indicating lamp	1 no.	for each Circuit breaker
j.	Red indicating lamp	1 no.	for each isolator
k.	Green indicating lamp	1 no.	for each Circuit breaker
l.	Green indicating lamp	1 no.	for each isolator
m.	White indicating lamp (DC healthy lamp)	2 nos.	for each feeder
n.	Annunciation windows with associated annunciation relays	18 nos.	for each feeder
o.	Push button for alarm Accept/reset/lamp test	3 nos.	for each control panel
p.	Synchronising Socket	1 no.	for each Circuit Breaker, if required
q.	Synchronising selector Switch	1 no.	for each Circuit Breaker switch, if required
r.	Protection Transfer Switch	1 no.	for each breaker in case of DMT /DM with bypass isolator / SMT schemes (Except TBC and BC breaker)
s.	Mimic to represent SLD	Lot	in all control panels
t.	Voltmeter with selector Switch	1 no.	for each line, transformer, bus reactor
u.	Cut out, mounting and wiring for RWTI and selector switch	Lot	for transformers/reactors

Notes:

1 For transformer feeders, all equipments of control panel shall be provided separately for HV and MV sides.

2. In case of incomplete diameter (D and I type layouts), control panel shall be equipped fully as if the diameter is complete, unless otherwise specified. Annunciation relays shall also be provided for the same and if required, necessary panel shall be supplied to accommodate the same.

3. The above list of equipments mentioned for control panel is generally applicable unless it is defined elsewhere and in case of bay extension in existing substations, necessary equipments for matching the existing control panel shall be supplied.

4. Each line /HV side of transformer/MV/LV side of transformer /Bus

reactor /TBC /**Tie** / BC/ Bus Section shall be considered as one feeder for above purpose.

VI) <u>CONTROL PANEL WITH BAY CONTROL UNIT (BCU):</u> Various types of control panels shall consist of the following:

a.	Bay Control Unit (BCU)	1 set	for each Circuit Breaker
b.	Ethernet switch complying IEC61850	1 no.	for each control panel
c.	Selector switch for Local/Remote bay control	1 no.	for each Circuit Breaker
d.	Ammeter with transducer & Selector switch	1 set	for each Line, BC, TBC, Bus section, Bus reactor, Transformer and line reactor
e.	CB Control switch	1 no.	for each Circuit breaker
f.	Red indicating lamp	1 no.	for each Circuit breaker
g.	Green indicating lamp	1 no.	for each Circuit breaker
h.	White indicating lamp (DC healthy lamp)	2 nos	for each feeder
i.	Common Annunciation lamp	1 no.	for each control panel
j.	Common hooter	1 no.	for each control panel
k.	Synchronising Socket	1 no.	for each Circuit Breaker if required
l.	Synchronising selector Switch	1 no.	for each Circuit Breaker switch if required
m.	Protection Transfer Switch	1 no.	for each breaker in case of DMT /DM with bypass isolator/ SMT schemes (Except TBC and BC breaker)
n.	Mimic to represent SLD	Lot	in all control panels
o.	Voltmeter with selector Switch	1 no.	for each line, transformer, bus reactor

Notes:

1 For transformer feeders, all equipments of control panel shall be provided separately for HV and MV sides.

2. In case of incomplete diameter (D and I type layouts), control panel shall be equipped fully as if the diameter is complete, unless otherwise specified. Annunciation relays shall also be provided for the same and if required, necessary panel shall be supplied to accommodate the same.

3. The above list of equipments mentioned for control panel is generally applicable unless it is defined elsewhere and in case of bay extension in existing substations, necessary equipments for matching the existing control panel, if applicable, shall be supplied.

4. Each line /HV side of transformer/MV/LV side of transformer /Bus reactor /TBC /BC/ Bus Section shall be considered as one feeder for above purpose.

6. **Control panel with BCU can be combined in the CB relay panels being supplied under present scope.**

7. The Bay Control unit and the numerical relays supplied under present scope shall be connected to the Ethernet switch. The ethernet switch shall comply with IEC 61850-3 requirements. It shall have sufficient number of ports to accommodate all the IEDs of the new bays and at least 6 spare ports for integrating the numerical Relays/BCUs with NTAMC system i.e. redundant Gateways/RTU and redundant SDC and two spare ports. The IP addressing scheme for the devices shall be provided.

9. Selector switch for Local/Remote bay control shall be provided to transfer the control between the BCU and the Control panel. The control shall be available to either the BCU or from the Control panel however data monitoring shall be available at both the devices

10. The Bay control unit shall be flush mounted in the panel with their mimic displays accessible from the front of the panel. The Bay control unit mimic shall dynamically represent the current value of the measurements, state of the devices and control of devices. The Bay control unit shall provide telemetry and tele-control for remote operation from control centres (NTAMC). The Bay control unit shall acquire all the analog measurements, Status of Circuit breakers, Isolators and Earth switches, status of alarms, and provide Control of devices (Circuit breaker/Isolators/Reset of Relays/position selection for Auto reclose etc). The Bay control unit shall also provide synchronization check facility for the circuit breakers suitable for the bus bar scheme.

11. For Protection transfer switch function in Transfer bus schemes- The High Speed Bi-stable relays for protection transfer from 'Normal' to 'Transfer' and vice versa, whose position can be controlled locally as well as from remote via BCU shall be provided. The position once selected should not change in case of Power cycling.

12. In case the control panel is being provided in switchyard panel room, its common alarm signal shall also initiate an alarm facia in any of the existing control panel in control room building.

37. ERECTION AND MAINTENANCE TOOL EQUIPMENTS

All special testing equipment required for the installation and maintenance of the apparatus, instruments devices shall be furnished in relevant schedule.

38. TROPICALISATION

Control room/ **Panel room** will be normally air-cooled/air- conditioned. All equipments shall however be suitable for installation in a tropical monsoon area having hot, humid climate and dry and dusty seasons with ambient conditions specified in the specification. All control wiring, equipment and accessories shall be protected against fungus growth, condensation, vermin and other harmful effects due to tropical environment.

39. TYPE TESTS

39.1. The reports for following type tests shall be submitted during detailed engineering for the Protective relays, Fault Recorder, Fault locator and Disturbance recorder:

a) Insulation tests as per IEC 60255-5

b) DC Voltage dips and interruptions/Variation as per IEC 61000-4-29 **or IEC 60255-11**

c) High frequency (1MHz burst) disturbance test **as per IEC 60255-22-1** (Not applicable for electromechanical relays)

d) Electrostatic discharges as per IEC 61000-4-2, level; 4 **or IEC 60255-22-2 with severity Class III** (not applicable for Electromechanical relays)

e) Fast transient test as per IEC 61000, Level IV **or IEC 60255-22-4 with severity level IV** (Not applicable for electromechanical relays)

f) Relay characteristics, performance and accuracy test as per IEC 60255

- Steady state Characteristics and operating time
- Dynamic Characteristics and operating time for distance protection relays and current differential protection relays
- Conformance test as per IEC 61850-10.

For Fault recorder, Disturbance recorder; only performance tests are intended under this item.

g) Tests for thermal requirements as per IEC 60255-6

h) Tests for rated burden as per IEC 60255-6

i) Contact performance test as per IEC 60255-0-20 **or IEC61810-2** (not applicable for Distance to fault locator and Disturbance recorder)

j) **Tests for mechanical requirements (Vibration, shock & bumps and seismic) as per IEC 60255-21-1, 2 & 3 with severity class-I**

k) **Test for Radiated Electromagnetic Field Disturbance as per IEC 60255-22-3 with severity class III** (not applicable for electromechanical relays)

In case there is a change either in version or in model (Except firmware) of the relay, the contractor shall submit the type test reports for the offered revision/model.

39.2. Steady state & Dynamic characteristics test reports on the distance protection relays, as type test, shall be based on test programme specified in Appendix A on simulator/network analyser/PTL. Alternatively, the files generated using Electromagnetic transient Programme (EMTP) can also be used for carrying out the above tests. Single source dynamic tests on transformer differential relay shall be/ should have been conducted based on general guidelines specified in CIGRE committee 34 report onEvaluation of characteristics and performance of Power system protection relays and protective systems.

40. Other general requirement for Protection IEDs:

a. Relay setting template (in editable document format) shall be provided by the contractor for each typical protection IEDs for relay setting purpose.

b. EMPLOYER has standardised binary input/output details, indication details, DR signals texts etc. of protection IEDs & Protection Panels CT/VT circuit termination detail and same shall be provided to contractor during detail engineering for preparation of schematics. Panel nomenclature, terminal blocks identification, as applicable, shall be according to typical detail given at APPENDIX-B.

41. Requirement for GIS substations:

GIS Gas zone trip signals, if provided, for each gas tight compartments (gas zone) in the GIS LCC shall be integrated in the protection schematics to provide electrical isolation of faulty Gas zone by tripping/ inter-tripping its adjacent circuit breakers. The scheme shall be implemented through protection IEDs and auxiliary relay as required.

APPENDIX-A

Test programme for distance relays

General Comments:

1. These test cases are evolved from the report of working group 04 of study committee 34 (Protection) on evaluation of characteristics and performance of power system protection relays and protective systems. For any further guidelines required for carrying out the tests, reference may be made to the above document.
2. The test shall be carried out using network configuration and system parameters as shown in the figure-1
3. All denotations regarding fault location, breakers etc are referred in figure –1
4. The fault inception angles are referred to R- N voltage for all types of faults
5. The fault inception angle is zero degree unless otherwise specified
6. Where not stated specifically, the fault resistance (Rf) shall be zero or minimum as possible in simulator
7. Single pole circuit breakers are to be used
8. The power flow in double source test is 500 MW

System parameters

System voltage =400KV

CTR= 1000/1

PTR = 400000/110 (with CVT, the parameters of CVT model are shown in figure –2)

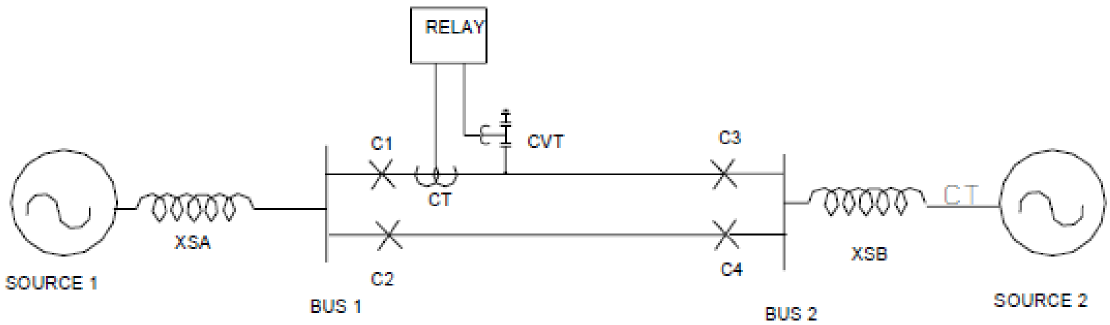


FIGURE 1

Line parameters/km

Positive Sequence Resistance, (r1) = 0. 02897 Ω
Positive Sequence Reactance (x1) = 0.3072 Ω
Zero Sequence Resistance (r0) = 0.2597 Ω
Zero Sequence Reactance (x1) = 1.0223 Ω
Zero Sequence Mutual Resistance (rm) = 0.2281 Ω
Zero Sequence Mutual Reactance (xm) = 0.6221 Ω

Zero Sequence succeptance (bo) = 2.347 μ mho

Positive Sequence succeptance (b1) =3.630 μ mho

Type of line	Short		Long
Secondary line impedance	2 Ω		20 Ω*
Length of line in Kms	23.57		235.7
1. SIR	4	15	4
Source impedance (pry) (at a time constant of 50 ms)	29.09 Ω (5500 MVA)	109.09 Ω (1467 MVA)	290.9 Ω (550 MVA)

* Alternatively, the tests can be done with 10 Ω secondary impedance and source impedance may accordingly be modified

<u>CVT Model</u>

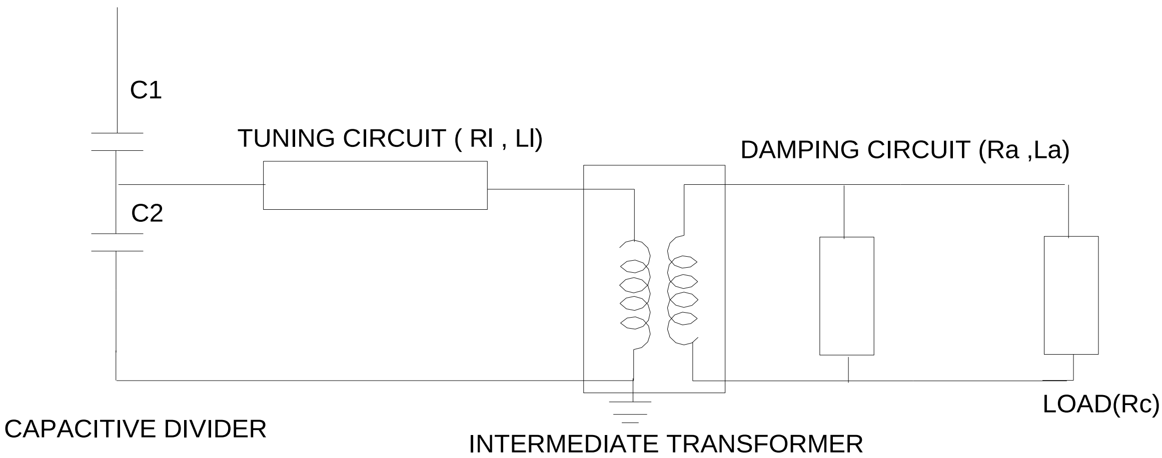


Figure-2

XC1	1.455 μ mho
XC2	27.646 μ mho
Rl	320 Ω
XLl	34243 Ω
Ra	4.200 Ω
Xla	197.92 Ω
Rc	14.00 Ω
Transformation ratio of Intermediate transformer	181.8

Details of fault cases to be done

SN	Description	Single source with short line (2 Ω)		Single source long line (20 Ω)	Double source with short double line (2 Ω)	Double source with long single line (20 Ω)
		CLOSE C1, OPEN C2,C3,C4		CLOSE C1, OPEN C2,C3,C4	CLOSE C1, C2,C3,C4	CLOSE C1,C3 OPEN C2,C4
		SIR=4	SIR=15	SIR =4	SIR = 4	SIR=4
1	Dynamic accuracy for zone 1	Tests to be done at 2 locations (84 % and 76 % of line length) X 4 faults (RN , YB, YBN, RYB) X 2 fault inception angle (0°, 90°)= 16 cases	Tests to be done at 2 locations (84 % and 76 % of line length) X 4 faults (RN , YB, YBN, RYB) X 2 fault inception angle (0°,90°)= 16 cases	Tests to be done at 2 locations (84 % and 76 % of line length) X 4 faults (RN , YB, YBN, RYB) X 2 fault inception angle (0°,90°)= 16 cases		Tests to be done at 2 locations (84% and 76% of line length) X 4 faults (RN , YB, YBN, RYB) X 2 fault inception angle (0°, 90°)= 16 cases
2	Operating time for zone 1 at SIR =4	Tests to be done at 3 locations (0% , 40% and 64% of line length) X 4 faults (RN, YB, YBN, RYB) X 4 fault inception angle (0°, 30°,60° and 90°) = 48 cases	Tests to be done at 3 locations (0 % , 40 % and 64 % of line length) X 4 faults (RN , YB, YBN, RYB) X 4 fault inception angle (0°,30°,60°and 90°)= 48 cases	Tests to be done at 3 locations (0 % , 40 % and 64 % of line length) X 4 faults (RN , YB, YBN, RYB) X 4 fault inception angle (0°, 30°,60° and 90°)= 48 cases	Tests to be done at 1 location (40 % of line length) X 4 faults (RN, YB, YBN, RYB) X 4 fault inception angle (0°,30°,60° and 90 °)= 16 cases	Tests to be done at 1 location (40 % of line length) X 4 faults (RN, YB, YBN, RYB) X 4 fault inception angle (0°,30°,60° and 90°)= 16cases
3	Operating time for zone II and Zone III	Tests to be done at 1 location (100 % of line length) X 1 faults (RN, YB, YBN, RYB) X 2 zones (II and III) = 2 cases	Tests to be done at 1 location (100 % of line length) X 1 faults (RN , YB, YBN, RYB) X 2 zones (II and III) = 2 cases	Tests to be done at 1 location (100 % of line length) X 1 faults (RN , YB, YBN, RYB) X 2 Zones (II and III) = 2 cases		

4	Switch on to fault feature			Tests to be done at 2 location (0 % and 32 %) X 1 faults (RYB) Any fault inception angle = 2 cases		
5	Operation during current reversal				Tests to be done at 2 location (0 % and 80 % of line length) X 1 faults (RN) X 1 fault inception angle (0 degrees) = 2 cases	
		CLOSE C1, OPEN C2,C3,C4		CLOSE C1, OPEN C2,C3,C4	CLOSE C1, C2,C3,C4	CLOSE C1,C3 OPEN C2,C4
		SIR=4	SIR=15	SIR =4	SIR = 4	SIR=4
6	Operation at simultaneous faults				Tests to be done at 2 location (8 % and 64 % of line length) X 2 faults (RN in circuit 1 to BN in circuit 2 and RN in circuit 1 to RYN in circuit 2 in 10 ms) X 1 fault inception angle (0 °) = 4 cases (*1)	
7	Directional sensitivity					Tests to be done at 1 location (0% reverse) X 6 faults (RN

						,YB, YBN , RYB,RN with Rf=13.75 ohm(sec) and RYN with Rf= 13.75 Ohm (sec) X 2 fault inception angle (0° ,90°) = 12cases
8	Limit for fault resistance					Tests to be done at 2 location (0% and 68 % of line length) X 1 fault (RN with Rf=13.75 ohm(sec) X 2 fault inception angle (0°,90°) = 4 cases
9	Operation at evolving faults					Tests to be done at 2 location (32 % and 0% of line length) X 2 faults (RN to RYN) x in 2 timings (10 ms and 30 ms) X 2 load direction (from A to B and from B to A) = 16 cases
9	Fault locator function , in case the same is offered as built in	Measure fault location for all cases under 1 and 2	Measure fault location for all cases under 1 and 2	Measure fault location for all cases under 1 and 2	Measure fault location for all cases under 2 and 6	Measure fault location for all cases under 2, 7 and 9

APPENDIX-B

Terminal Block (TB) Nomenclature for Relay & interface panels

Circuit type	TB for external connections	TB for Interpanel connections
CT	X:CT	XI:CT
PT	X:VT	XI:VT
AC Auxiliary	X:AC	XI:AC
DC Auxiliary	X:DC	XI:DC
Trip Circuit 1	X:TC1	XI:TC1
Trip Circuit 2	X:TC2	XI:TC2
LBB & BB	X:LBB	XI:LBB
CB	X:CB/X:CBT	XI:X
ISOLATOR	X:ISA/ISB/ISL/ISR	XI:X
EARTH SWITCH	X:ES	XI:X
PROTECTION COUPLER	X:PC	XI:PC
ENERGY METER	X:EM	---
Reactor	X:SR	XI:SR
Transformer	X:AT	XI:AT
Others Control & status signals	X:X	XI:X

Feeder relay Panels designation:

Typical Bay / Busbar	Panel Ref.
400kV Bay no. 1 (401)	4R1A, 4R1B and so on
220kV Bay no. 1 (201)	2R1A, 2R1B and so on
132kV Bay no. 1 (101)	1R1A, 1R1B and so on
Bus 400kV	4BB1, 4BB2 and so on
Bus220kV	2BB1, 2BB2 and so on
Bus132kV	1BB1, 1BB2 and so on

CHAPTER 18: SUBSTATION AUTOMATION SYSTEM

1.0 GENERAL

1.1. The Substation Automation System (SAS) shall be installed to control and monitor all the sub-station equipment from remote control centre (RCC) as well as from local control centre.

The SAS shall contain the following main functional parts:

- Bay control Intelligence Electronic Devices (IEDs) for control and monitoring.
- Station Human Machine Interface (HMI)
- Redundant managed switched Ethernet Local Area Network communication infrastructure with hot standby.
- Gateway for remote control via industrial grade hardware (to RCC) through IEC60870-5-101 protocol.
- Gateway for remote supervisory control (to LDC Kathmandu), the gateway should be able to communicate with LDC on IEC 60870-5-101 protocol. The specific protocol to be implemented is enclosed as Annexure-II. It shall be the bidder's responsibility to integrate his offered system with existing LDC system for exchange of desired data. The requirement of IO point shall be worked out by the bidder as per criterion enclosed as Annexure-III for data exchange with **LDC**.
- Remote HMI.
- Peripheral equipment like printers, display units, key boards, Mouse etc.

1.2. It shall enable local station control via a PC by means of human machine interface (HMI) and control software package, which shall contain an extensive range of supervisory control and data acquisition (SCADA) functions.

1.3. 1.4. It shall include communication gateway, intelligent electronic devices
1.4. (IED) for bay control and inter IED communication infrastructure. An architecture drawing for SAS is enclosed.

1.5. The communication gateway shall facilitate the information flow with remote control centres. The bay level intelligent electronic devices (IED) for protection and control shall provide the direct connection to the switchgear without the need of interposing components and perform control, protection, and monitoring functions.

2. System design

2.1 General system design

The Substation Automation System (SAS) shall be suitable for operation and monitoring of the complete substation including future extensions as well as able to integrate to the existing SAS as given in Chapter 1 - PSR.

The systems shall be of the state-of-the art suitable for operation under electrical environment present in extra high voltage substations, follow the latest engineering practice, and ensure long-term compatibility requirements and continuity of equipment supply and the safety of the operating staff.

The offered SAS shall support remote control and monitoring from Remote Control centres via gateways.

The system shall be designed such that personnel without any background knowledge in Microprocessor-based technology are able to operate the system. The operator interface shall be intuitive such that operating personnel shall be able to operate the system easily after having received some basic training.

The system shall incorporate the control, monitoring and protection functions specified, self-monitoring, signalling and testing facilities, measuring as well as memory functions, event recording and evaluation of disturbance records.

Maintenance, modification or extension of components may not cause a shutdown of the whole substation automation system. Self-monitoring of components, modules and communication shall be incorporated to increase the availability and the reliability of the equipment and minimize maintenance.

Bidder shall offer the Bay level unit (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer), bay mimic along with relay and protection panels and Communication panels (described in other Chapters of technical specifications) housed in air-conditioned GIS Panel Room suitably located in switchyard and Station HMI in Control Room building for overall optimisation in respect of cabling and control room building.

2.2 System architecture

The SAS shall be based on a decentralized architecture and on a concept of bay-oriented, distributed intelligence.

Functions shall be decentralized, object-oriented and located as close as possible to the process.

The main process information of the station shall be stored in distributed databases. The typical SAS architecture shall be structured in two levels, i.e. in a station and a bay level.

At bay level, the IEDs shall provide all bay level functions regarding control, monitoring and protection, inputs for status indication and outputs for commands. The IEDs should be directly connected to the switchgear without any need for additional interposition or transducers.

Each bay control IED shall be independent from each other and its functioning shall not be affected by any fault occurring in any of the other bay control units of the station.

The data exchange between the electronic devices on bay and station level shall take place via the communication infrastructure. This shall be realized using fibre-optic cables, thereby guaranteeing disturbance free communication. The fibre optic cables shall be run in GI conduit pipes. Data exchange is to be realised using IEC 61850 protocol with a redundant managed switched Ethernet communication infrastructure

The communication shall be made in fault tolerant ring in redundant mode, excluding the links between individual bay IEDs to switch wherein the redundant connections are not envisaged, such that failure of one set of fiber shall not affect the normal operation of the SAS. However failure of fiber shall be alarmed in SAS. Each fiber optic cable shall have four (4) spare fibers

At station level, the entire station shall be controlled and supervised from the station HMI. It shall also be possible to control and monitor the bay from the bay level equipment at all times.

Clear control priorities shall prevent operation of a single switch at the same time from more than one of the various control levels, i.e. RCC, station HMI, bay level or apparatus level. The priority shall always be on the lowest enabled control level.

The station level contains the station-oriented functions, which cannot be realised at bay level, e.g. alarm list or event list related to the entire substation, gateway for the communication with remote control centres.

The GPS time synchronising signal (as specified in the Chapters relay & protection) for the synchronization of the entire system shall be provided.

The SAS shall contain the functional parts as described in para 1.2 above.

2.3 FUNCTIONAL REQUIREMENTS

The high-voltage apparatus within the station shall be operated from different places:

- Remote control centres
- Station HMI.
- Local Bay controller IED (in the bays)

Operation shall be possible by only one operator at a time.

The operation shall depend on the conditions of other functions, such as interlocking, synchro check, etc. (see description in"Bay level control functions").

2.3.1 Select-before-execute

For security reasons the command is always to be given in two stages: selection of the object and command for operation under all mode of operation except emergency operation. Final execution shall take place only when selection and command are actuated.

2.3.2 Command supervision

Bay/station interlocking and blocking

Software Interlocking is to be provided to ensure that inadvertent incorrect operation of switchgear causing damage and accidents in case of false operation does not take place.

In addition to software interlocking hardwired interlocking are to be provided for:

(a) Bus Earth switch Interlocking

(b) Transfer Bus interlocking (if applicable)

It shall be a simple layout, easy to test and simple to handle when upgrading the station with future bays. For software interlocking the bidder shall describe the scenario while an IED of another bay is switched off or fails.

A software interlock override function shall be provided which can be enabled to bypass the interlocking function.

2.3.3 Run Time Command cancellation

Command execution timer (configurable) must be available for each control level connection. If the control action is not completed within a specified time, the command should get cancelled.

2.3.4 Self-supervision

Continuous self-supervision function with self-diagnostic feature shall be included.

2.3.5 User configuration

The monitoring, controlling and configuration of all input and output logical signals and binary inputs and relay outputs for all built-in functions and signals shall be possible both locally and remotely.

It shall also be possible to interconnect and derive input and output signals, logic functions, using built-In functions, complex voltage and currents, additional logics (AND-gates, OR gates and timers). (Multi-activation of these additional functions should be possible).

The Functional requirement shall be divided into following levels:

a. Bay (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer) Level Functions

b. System Level Functions

3.1. Bay level functions

In a decentralized architecture the functionality shall be as close to the process as possible. In this respect, the following functions can be allocated at bay level:

- Bay control functions including data collection functionality in bay control/protection unit.
- Bay protection functions

Separate IEDs shall be provided for bay control function and bay protection function.

3.1.1. Bay control functions

3.1.1.1. Overview

Functions

- Control mode selection
- Select-before-execute principle
- Command supervision:
    - Interlocking and blocking
    - Double command
- Synchrocheck, voltage selection
- Run Time Command cancellation

- Transformer tap changer control (Raise and lower of tap) (for power transformer bays)
- Operation counters for circuit breakers and pumps
- Hydraulic pump/ Air compressor runtime supervision
- Operating pressure supervision through digital contacts only
- Breaker position indication per phase
- Alarm annunciation
- Measurement display
- Local HMI (local guided, emergency mode)
- Interface to the station HMI.
- Data storage for at least 200 events
- Extension possibilities with additional I/O's inside the unit or via fibre-optic communication and process bus

3.1.1.2. Control mode selection

Bay level Operation:

As soon as the operator receives the operation access at bay level the operation is normally performed via bay control IED. During normal operation bay control unit allows the safe operation of all switching devices via the bay control IED.

EMERGENCY Operation

It shall be possible to close or open the selected Circuit Breaker with ON or OFF push buttons even during the outage of bay IED**.**

REMOTE mode

Control authority in this mode is given to a higher level (Remote Control Centre) and the installation can be controlled only remotely. Control operation from lower levels shall not be possible in this operating mode.

3.1.1.3. Synchronism and energizing check

The synchronism and energizing check functions shall be bay-oriented and distributed to the bay control and/or protection devices. These features are:

- Settable voltage, phase angle, and frequency difference.
- Energizing for dead line - live bus, live line - dead bus or dead line – dead bus with no synchro-check function.
- Synchronising between live line and live bus with synchro-check function

Voltage selection

The voltages relevant for the Synchro check functions are dependent on the station topology, i.e. on the positions of the circuit breakers and/or the isolators. The correct voltage for synchronizing and energizing is derived from the auxiliary switches of the circuit breakers, the isolator, and earthing switch and shall be selected automatically by the bay control and protection IEDs.

3.1.1.4. Transformer tap changer control

Raise and lower operation of OLTC taps of transformer shall be facilitated through Bay controller IED.

3.1.2. Bay protection functions

3.1.2.1. General

The protection functions are independent of bay control function. The protection shall be provided by separate protection IEDs (numerical relays) and other protection devices as per Chapters Relay & Protection.

IEDs, shall be connected to the communication infrastructure for data sharing and meet the real-time communication requirements for automatic functions. The data presentation and the configuration of the various IEDs shall be compatible with the overall system communication and data exchange requirements.

Event and disturbance recording function

Each IED should contain an event recorder capable of storing at least 200 time-tagged events. The disturbance recorder function shall be as per detailed in Chapter 17 – Control, Relay & Protection Panels.

3.1.2.2. **Bay Monitoring Function:**

Analogue inputs for voltage and current measurements shall be connected directly to the voltage transformers (VT) and the current transformers (CT) without intermediate transducers. The values of active power (W), reactive power (VAR), frequency (Hz), and the rms values for voltage (U) and current (I) shall be calculated in the Bay control/protection unit.

3.2. System level functions

3.2.1. Status supervision

The position of each switchgear, e.g. circuit breaker, isolator, earthing switch, transformer tap changer etc., shall be supervised continuously. Every detected change of position shall be immediately displayed in the single-line diagram on the station HMI screen, recorded in the event list, and a hard copy printout shall be produced. Alarms shall be initiated in the case of spontaneous position changes.

The switchgear positions shall be indicated by two auxiliary switches, normally closed (NC) and normally open (NO), which shall give ambivalent signals. An alarm shall be initiated if these position indications are inconsistent or if the time required for operating mechanism to change position exceeds a predefined limit.

The SAS shall also monitor the status of sub-station auxiliaries. The status and control of auxiliaries shall be done through separate one or more IED and all alarm and analogue values shall be monitored and recoded through this IED.

3.2.2. Measurements

The analogue values acquired/calculated in bay control/protection unit shall be displayed locally on the station HMI and in the control centre. The abnormal values must be discarded. The analogue values shall be updated every 2 seconds.

Threshold limit values shall be selectable for alarm indications.

3.2.3. Event and alarm handling

Events and alarms are generated either by the switchgear, by the control IEDs, or by the station level unit. They shall be recorded in an event list in the station HMI. Alarms shall be recorded in a separate alarm list and appear on the screen. All, or a freely selectable group of events and alarms shall also be printed out on an event printer. The alarms and events shall be time-tagged with a time resolution of 1 ms. The tentative list for various feeders and systems are enclosed as Annexure-I

3.2.4. Station HMI

3.2.4.1. Substation HMI Operation:

On the HMI the object has to be selected first. In case of a blocking or interlocking conditions are not met, the selection shall not be possible and an appropriate alarm annunciation shall occur. If a selection is valid the position indication will show the possible direction, and the appropriate control execution button shall be pressed in order to close or open the corresponding object.

Control operation from other places (e.g. REMOTE) shall not be possible in this operating mode.

3.2.4.2. Presentation and dialogues

General

The operator station HMI shall be a redundant with hot standby and shall provide basic functions for supervision and control of the substation. The operator shall give commands to the switchgear on the screen via mouse clicks.

The HMI shall give the operator access to alarms and events displayed on the screen. Aside from these lists on the screen, there shall be a printout of alarms or events in an event log.

An acoustic alarm shall indicate abnormalities, and all unacknowledged alarms shall be accessible from any screen selected by the operator.

The following standard pictures shall be available from the HMI:

- Single-line diagram showing the switchgear status and measured values
- Control dialogues with interlocking or blocking information details. This control dialogue shall tell the operator whether the device operation is permitted or blocked.
- Measurement dialogues
- Alarm list, station / bay-oriented
- Event list, station / bay-oriented
- System status

3.2.4.3. HMI design principles

Consistent design principles shall be adopted with the HMI concerning labels, colours, dialogues and fonts. Non-valid selections shall be dimmed out.

The object status shall be indicated using different status colours for:

- Selected object under command
- Selected on the screen
- Not updated, obsolete values, not in use or not sampled
- Alarm or faulty state
- Warning or blocked
- Update blocked or manually updated
- Control blocked
- Normal state

3.2.4.4. Process status displays and command procedures

The process status of the substation in terms of actual values of currents, voltages, frequency, active and reactive powers as well as the positions of circuit breakers, isolators and transformer tap-changers shall be displayed in the station single-line diagram.

In order to ensure a high degree of security against undesired operation, a "select-before-execute" command procedure shall be provided. After the "selection" of a switch, the operator shall be able to recognize the selected device on the screen, and all other switchgear shall be blocked. As communication between control centre and device to be controlled is established, the operator shall be prompted to confirm the control action and only then final execute command shall be accepted**.** After the "execution" of the command the operated switching symbol shall flash until the switch has reached its new position.

The operator shall be in a position to execute a command only, if the switch is not blocked and if no interlocking condition is going to be violated. The interlocking statements shall be checked by the interlocking scheme implemented at bay and station level.

After command execution the operator shall receive a confirmation that the new switching position has been reached or an indication that the switching procedure was unsuccessful with the indication of the reason for non-functioning.

3.2.4.5. System supervision & display

The SAS system shall be comprehensively self-monitored such that faults are immediately indicated to the operator, possibly before they develop into serious situations. Such faults are recorded as a faulty status in a system supervision display. This display shall cover the status of the entire substation including all switchgear, IEDs, communication infrastructure and remote communication links, and printers at the station level, etc.

3.2.4.6. Event list

The event list shall contain events that are important for the control and monitoring of the substation.

The event and associated time (with1 ms resolution) of its occurrence has to be displayed for each event.

The operator shall be able to call up the chronological event list on the monitor at any time for the whole substation or sections of it.

A printout of each display shall be possible on the hard copy printer.

The events shall be registered in a chronological event list in which the type of event and its time of occurrence are specified. It shall be possible to store all events in the computer for at least one month. The information shall be obtainable also from a printed event log.

The chronological event list shall contain:

- Position changes of circuit breakers, isolators and earthing devices
- Indication of protective relay operations
- Fault signals from the switchgear
- Indication when analogue measured values exceed upper and lower limits. Suitable provision shall be made in the system to define two level of alarm on either side of the value or which shall be user defined for each measurands.
- Loss of communication.

Filters for selection of a certain type or group of events shall be available. The filters shall be designed to enable viewing of events grouped per:

- Date and time
- Bay
- Device
- Function e.g. trips, protection operations etc.
- Alarm class

3.2.4.7. Alarm list

Faults and errors occurring in the substation shall be listed in an alarm list and shall be immediately transmitted to the control centre. The alarm list shall substitute a conventional alarm tableau, and shall constitute an evaluation of all station alarms. It shall contain unacknowledged alarms and persisting faults. The date and time of occurrence shall be indicated.

The alarm list shall consist of a summary display of the present alarm situation. Each alarm shall be reported on one line that contains:

- The date and time of the alarm
- The name of the alarming object
- A descriptive text
- The acknowledgement state.

Whenever an alarm condition occurs, the alarm condition must be shown on the alarm list and must be displayed in a flashing state along with an audible alarm. After acknowledgement of the alarm, it should appear in a steady (i.e. not flashing) state and the audible alarm shall stop. The alarm should disappear only if the alarm condition has physically cleared and the operator has reset the alarm with a reset command. The state of the alarms shall be shown in the alarm list (Unacknowledged and persistent, Unacknowledged and cleared, Acknowledged and persistent).

Filters for selection of a certain type or group of alarms shall be available as for events.

3.2.4.8. Object picture

When selecting an object such as a circuit breaker or isolator in the single-line diagram, the associated bay picture shall be presented first. In the selected object picture, all attributes like

- Type of blocking
- Authority
- Local / remote control
- RSCC / SAS control
- Errors
- etc.,

shall be displayed.

3.2.4.9. Control dialogues

The operator shall give commands to the system by means of mouse click located on the single-line diagram. Data entry is performed with the keyboard. Dedicated control dialogues for controlling at least the following devices shall be available:

- Breaker and disconnector
- Transformer tap-changer

3.2.5. User-authority levels

It shall be possible to restrict activation of the process pictures of each object (bays, apparatus...) within a certain user authorisation group. Each user shall then be given access rights to each group of objects, e.g.:

- Display only
- Normal operation (e.g. open/close of switchgear)
- Restricted operation (e.g. by-passed interlocking)
- System administrator

For maintenance and engineering purposes of the station HMI, the following authorisation levels shall be available:

- No engineering allowed
- Engineering/configuration allowed
- Entire system management allowed

The access rights shall be defined by passwords assigned during the log-in procedure. Only the system administrator shall be able to add/remove users and change access rights.

3.2.6. Reports

The reports shall provide time-related follow-ups of measured and calculated values. The data displayed shall comprise:

- Trend reports:
  - Day (mean, peak)
  - Month (mean, peak)
  - Semi-annual (mean, peak)
  - Year (mean, peak)
- Historical reports of selected analogue Values:
  - Day (at 15 minutes interval)
  - Week
  - Month
  - Year

It shall be possible to select displayed values from the database in the process display on-line. Scrolling between e.g. days shall be possible. Unsure values shall be indicated. It shall be possible to select the time period for which the specific data are kept in the memory.

Following printouts shall be available from the printer and shall be printed on demand:

i. Daily voltage and frequency curves depicting time on X-axis and the appropriate parameters on the Y-axis. The time duration of the curve is 24 hours.

ii. Weekly trend curves for real and derived analogue values.

iii. Printouts of the maximum and minimum values and frequency of occurrence and duration of maximum and minimum values for each analogue parameter for each circuit in 24 hr period.

iv. Provision shall be made for logging information about breaker status like number of operation with date and time indications along with the current value it interrupts (in both condition i.e. manual opening and fault tripping)

v. Equipment operation details shift wise and during 24 hours.

vi. Printout on adjustable time period as well as on demand for MW, MVAR, Current, Voltage on each feeder and transformer as well as Tap Positions, temperature and status of pumps and fans for transformers.

vii. Printout on adjustable time period as well as on demand system frequency and average frequency.

viii. Reports in specified formats which shall be handed over to successful bidder. The bidder has to develop these reports. The reports are limited to the formats for which data is available in the SAS database.

3.2.7. Trend display (historical data)

It shall be possible to illustrate all types of process data as trends - input and output data, binary and analogue data. The trends shall be displayed in graphical form as column or curve diagrams with a maximum of 10 trends per screen. Adjustable time span and scaling ranges must be provided.

It shall be possible to change the type of value logging (direct, mean, sum, or difference) on-line in the window. It shall also be possible to change the update intervals on-line in the picture as well as the selection of threshold values for alarming purposes.

3.2.8. Automatic disturbance file transfer

All recorded data from the IEDs with integrated disturbance recorder as well as dedicated disturbance recording systems shall be automatically uploaded (event triggered or once per day) to a dedicated computer and be stored on the hard disc.

3.2.9. Disturbance analysis

The PC-based work station shall have necessary software to evaluate all the required information for proper fault analysis.

3.2.10. IED parameter setting

It shall be possible to access all protection and control IEDs for reading the parameters (settings) from the station HMI or from a dedicated monitoring computer. The setting of parameters or the activation of parameter sets shall only be allowed after entering a password.

3.2.11. Automatic sequences

The available automatic sequences in the system should be listed and described, (e.g. sequences related to the bus transfer). It must be possible to initiate pre-defined automatic sequences by the operator and also define new automatic sequences.

3.3. Gateway

3.3.1 Communication Interface

The Substation Automation System shall have the capability to support simultaneous communications with multiple independent remote master stations,

The Substation Automation System shall have communication ports as follows:

(a) Two ports for Remote Control Centre (RCC-Shall be located at Hetauda)
(b) Two ports for Load Dispatch Centre (LDC)

The communication interface to the SAS shall allow scanning and control of defined points within the substation automation system independently for each control centre. The substation automation system shall simultaneously respond to independent scans and commands from employer's control centres (RCC & LDC). The substation automation system shall support the use of a different communication data exchange rate (bits per second), scanning cycle, and/or communication protocol to each remote control centre. Also, each control centre’s data scan and control commands may be different for different data points within the substation automation system's database.

3.3.2 Remote Control Centre Communication Interface

<u>Employer</u> will supply communication channels between the Substation Automation System and the remote control centre. The communication channels provided by Employer will consist either of power line carrier, microwave, optical fibre, VSAT or leased line, the details of which shall be provided during detailed Engineering.

3.3.3 **Interface equipment:**

The Contractor shall provide interface equipment for communicating between Substation Automation system and Remote control centre and between Substation Automation system and LDC. However, the communication channels available for this purpose are specified in Chapter 1 - PSR.

3.3.4 Communication Protocol

The communication protocol for gateway to control centre must be open protocol and shall support IEC 60870-5-101 and IEC 61850 for all levels of communication for sub-station automation such as Bay to station HMI, gateway to remote station etc.

4.0 System hardware:

4.1 Redundant Station HMI, Remote HMI and Disturbance Recorder Work station:

The contractor shall provide redundant station HMI in hot standby mode. The servers used in these work stations shall be of industrial grade**.**

It shall be capable to perform all functions for entire substation including future requirements as indicated in the SLD. It shall use industrial grade components. Processor and RAM shall be selected in such a manner that during normal operation not more than 30% capacity of processing and memory are used. Supplier shall demonstrate these features.
The capacity of hard disk shall be selected such that the following requirement should occupy less than 50% of disk space:

1. Storage of all analogue data (at 15 Minutes interval)and digital data including alarm , event and trend data for thirty(30) days,
2. Storage of all necessary software,
3. 20GB space for OWNER'S use.

Supplier shall demonstrate that the capacity of hard disk is sufficient to meet the above requirement.

4.1.1 **HMI (Human Machine Interface**)

The VDU shall show overview diagrams (Single Line Diagrams) and complete details of the switchgear with a colour display. All event and alarm annunciation shall be selectable in the form of lists. Operation shall be by a user friendly function keyboard and a cursor positioning device. The user interface shall be based on WINDOWS concepts with graphics & facility for panning, scrolling, zooming, decluttering etc.

4.1.2 Visual Display Units/TFT's (Thin Film Technology)

The display units shall have high resolution and reflection protected picture screen. High stability of the picture geometry shall be ensured. The screen shall be at least 21" diagonally in size and capable of colour graphic displays.

The display shall accommodate resolution of 1280 X 1024 pixels.

4.1.3 Printer

It shall be robust & suitable for operation with a minimum of 132 characters per line. The printing operation shall be quiet with a noise level of less than 45 dB suitable for location in the control room. Printer shall accept and print all ASCII characters via master control computer unit interface.

The printer shall have in built testing facility. Failure of the printer shall be indicated in the Station HMI. The printer shall have an off line mode selector switch to enable safe maintenance. The maintenance should be simple with provisions for ease of change of print head, ribbon changing, paper insertion etc.

All reports and graphics prints shall be printed on laser printer. One dot matrix printer shall be exclusively used for hourly log printing.

All printers shall be continuously online.

4.1.4 Mass Storage Unit

The mass storage unit shall be built-in to the Station HMI. All operational measured values, and indications shall be stored in a mass-storage unit **in form** of **DVD RW** The unit should support at least Read (48X), Write(24X), and Re-Write (10X) operations, with Multi-Session capability. It should support ISO9660, Rockridge and Joliet Filesystems. It should support formatting and use under the operating system provided for Station HMI. The monthly back up of data shall be taken on disc. The facility of back up of data shall be inherent in the software**.**

4.1.5 Switched Ethernet Communication Infrastructure:

The bidder shall provide the redundant switched optical Ethernet communication infrastructure for SAS. One switch shall be provided to connect all IEDs for two bays of 400kV yard to communication infrastructure. Each switch shall have at least two spare ports for connecting bay level IEDs and one spare port for connecting station bus.

4.2 Bay level unit

The bay unit shall use industrial grade components. The bay level unit, based on microprocessor technology, shall use numerical techniques for the calculation and evaluation of externally input analogue signals. They shall incorporate select-before-operate control principles as safety measures for operation via the HMI. They shall perform all bay related functions, such as control commands, bay interlocking, data acquisition, data storage, event recording and shall provide inputs for status indication and outputs for commands. They shall be directly connected to the switchgear. The bay unit shall acquire and process all data for the bay (Equipment status, fault indications, measured values, alarms etc.) and transmit these to the other devices in sub-station automation system. In addition, this shall receive the operation commands from station HMI and control centre. The bay unit shall have the capability to store all the data for at least 24 hours.

One number Bay level unit shall be provided for supervision and control of each 400/220 kV bay (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer). The Bay level unit shall be equipped with analogue and binary inputs/outputs for handling the control, status monitoring and analogue measurement functions. All bay level interlocks are to be incorporated in the Bay level unit so as to permit control from the Bay level unit/ local bay mimic panel, with all bay interlocks in place, during maintenance and commissioning or in case of contingencies when the Station HMI is out of service.

The bay control unit to be provided for the bays shall be preferably installed in the CB relay panel/feeder protection panel for respective bay. Further in case of one and half breaker schemes, the BCU for Tie CB shall be provided in Tie CB relay panel. The tie CB relay panel shall also house the Ethernet switch(es) to be provided for the diameter. The bay control unit for future bay (if required as per Chapter-PSR) shall be installed in a separate panel.The bay control unit to be provided for the bays shall be preferably installed in the CB relay panel/feeder protection panel for respective bay.

The Bay level unit shall meet the requirements for withstanding electromagnetic interference according to relevant parts of IEC 61850. Failure of any single component within the equipment shall neither cause unwanted operation nor lead to a complete system breakdown.

4.2.1 Input/Output (I/O) modules

The I/O modules shall form a part of the bay level unit and shall provide coupling to the substation equipment. The I/O modules shall acquire all switchgear information (i.e. data coming directly from the switchgear or from switchgear interlocking devices) and transmit commands for operation of the switchgear. The measured values of voltage and current shall be from the secondaries of instrument transformers. The digital inputs shall be acquired by exception with 1 ms resolution. Contact bouncing in digital inputs shall not be assumed as change of state

4.3 Control Building Panel Room:

The Control Building panel room shall be constructed to house Bay level units, bay mimic, relay and protection panels, communication panels etc. Panel room shall have necessary space for accommodating the future bay IEDs. The layout of equipment/panel shall be subject to Owner's approval. The panel room shall be provided with necessary illuminations, fire alarm system with at least four detectors with necessary power supply if required and it shall be wired to SAS. The air conditioner provided in panel room shall be monitored from substation automation system.

4.4 Extendibility in future

Offered substation automation system shall be suitable for extension in future for additional bays. During such requirement, all the drawings and configurations, alarm/event list etc. displayed shall be designed in such a manner that its extension shall be easily performed by the employer. During such event, normal operation of the existing substation shall be unaffected and system shall not require a shutdown. The contractor shall provide all necessary software tools along with source codes to perform addition of bays in future and complete integration with SAS by the user. These software tools shall be able to configure IED, add additional analogue variable, alarm list, event list, modify interlocking logics etc. for additional bays/equipment which shall be added in future.

5.0 Software structure

The software package shall be structured according to the SAS architecture and strictly divided in various levels. Necessary firewall shall be provided at suitable points in software to protect the system. An extension of the station shall be possible with lowest possible efforts. Maintenance, modification or an extension of components of any feeder may not force a shut-down of the parts of the system which are not affected by the system adaptation.

5.1.1 Station level software

5.1.1.1 Human-machine interface (HMI)

The base HMI software package for the operator station shall include the main SAS functions and it shall be independent of project specific hardware version and operating system. It shall further include tools for picture editing, engineering and system configuration. The system shall be easy to use, to maintain, and to adapt according to specific user requirements. Systems shall contain a library with standard functions and applications.

5.1.2 Bay level software

5.1.1.1 System software

The system software shall be structured in various levels. This software shall be placed in a non-volatile memory. The lowest level shall assure system performance and contain basic functions, which shall not be accessible by the application and maintenance engineer for modifications. The system shall support the generation of typical control macros and a process database for user specific data storage. In case of restoration of links after failure, the software along with hardware shall be capable of automatically synchronising with the remaining system without any manual interface. This shall be demonstrated by contractor during integrated system test.

5.1.1.2 Application software

In order to ensure robust quality and reliable software functions, the main part of the application software shall consist of standard software modules built as functional block elements. The functional blocks shall be documented and thoroughly tested. They form part of a library.

The application software within the control/protection devices shall be programmed in a functional block language.

5.1.1.3 Network Management System (NMS):

The contractor shall provide a network management system software for following management functions:

a. Configuration Management
b. Fault Management
c. Performance Monitoring

This system shall be used for management of communication devices and other IEDs in the system. This NMS can be loaded in DR work-station and shall be easy to use, user friendly and menu based. The NMS shall monitor all the devices in the SAS and report if there is any fault in the monitored devices. The NMS shall

(a) Maintain performance, resource usage, and error statistics for all managed links and devices and present this information via displays, periodic reports and on demand reports.

(b) Maintain a graphical display of SAS connectivity and device status.

(c) Issue alarms when error conditions occurs

(d) Provide facility to add and delete addresses and links

5.1.1.4 The contractor shall provide each software in two copies in CD to load into the system in case of any problem related with Hardware/Communication etc.

6.0 TESTS

The substation automation system offered by the bidder shall be subjected to following tests to establish compliance with IEC 61850 for EHV sub-station equipment installed in sheltered area in the outdoor switchyard and specified ambient conditions:

6.1 Type Tests:

6.1.1 Control IEDs and Communication Equipment:

a. **Power Input:**
   i. Auxiliary Voltage
   ii. Current Circuits
   iii. Voltage Circuits
   iv. Indications

b. **Accuracy Tests:**
   i. Operational Measured Values
   ii. Currents
   iii. Voltages
   iv. Time resolution

c. **Insulation Tests:**
   i. Dielectric Tests
   ii. Impulse Voltage withstand Test

d. **Influencing Quantities**
   i. Limits of operation
   ii. Permissible ripples
   iii. Interruption of input voltage

e. **Electromagnetic Compatibility Test:**
   i. 1 MHZ. burst disturbance test

ii. Electrostatic Discharge Test
iii. Radiated Electromagnetic Field Disturbance Test
iv. Electrical Fast transient Disturbance Test
v. Conducted Disturbances Tests induced by Radio Frequency Field
vi. Magnetic Field Test
vii. Emission (Radio interference level) Test.
viii. Conducted Interference Test

f. Function Tests:

i. Indication
ii. Commands
iii. Measured value Acquisition
iv. Display Indications

g. Environmental tests:

i. Cold Temperature
ii. Dry Heat
iii. Wet heat
iv. Humidity (Damp heat Cycle)
v. Vibration
vi. Bump
vii. Shock

6.2 Factory Acceptance Tests:

The supplier shall submit a test specification for factory acceptance test (FAT) and commissioning tests of the station automation system for approval. For the individual bay level IED's applicable type test certificates shall be submitted**.**

The manufacturing and configuration phase of the SAS shall be concluded by the factory acceptance test (FAT). The purpose is to ensure that the Contractor has interpreted the specified requirements correctly and that the FAT includes checking to the degree required by the user. The general philosophy shall be to deliver a system to site only after it has been thoroughly tested and its specified performance has been verified, as far as site conditions can be simulated in a test lab. During FAT the entire Sub-station Automation System including complete control and protection system to be supplied under present scope shall be tested for complete functionality and configuration in factory itself. The extensive testing shall be carried out during FAT. The purpose of Factory Acceptance Testing is to ensure trouble free installation at site. No major configuration setting of system is envisaged at site.

If the complete system consists of parts from various suppliers or some parts are already installed on site, the FAT shall be limited to sub-system tests. In such a case, the complete system test shall be performed on site together with the site acceptance test (SAT).

6.2.1 Hardware Integration Tests:

The hardware integration test shall be performed on the specified systems to be used for Factory tests when the hardware has been installed in the factory. The operation of each item shall be verified as an integral part of system. Applicable hardware diagnostics shall be used to verify that each hardware component is completely operational and assembled into a configuration capable of supporting software integration and factory testing of the system. The equipment expansion capability shall also be verified during the hardware integration tests. The vendor specifically demonstrates how to add a device in future in SAS during FAT. The device shall be from a different manufacturer than the SAS supplier.

6.2.2 Integrated System Tests:

Integrated system tests shall verify the stability of the hardware and the software. During the tests all functions shall run concurrently and all equipment shall operate a continuous 100 Hours period. The integrated system test shall ensure the SAS is free of improper interactions between software and hardware while the system is operating as a whole.

6.3 Site Acceptance Tests:

The site acceptance tests (SAT) shall completely verify all the features of SAS hardware and software. The bidder shall submit the detailed SAT procedure and SAT procedure shall be read in conjunction with the specification.

7.0 SYSTEM OPERATION

7.1 SUBSTATION OPERATION

7.1.1 NORMAL OPERATION

Operation of the system by the operator from the remote RCC or at the substation shall take place via industry standard HMI(Human Machine interface) subsystem consisting of graphic colour VDU , a standard keyboard and a cursor positioning device (mouse).

The coloured screen shall be divided into 3 fields:

i) Message field with display of present time and date
ii) Display field for single line diagrams
iii) Navigation bar with alarm/condition indication

For display of alarm annunciation, lists of events etc a separate HMI View node shall be provided.

All operations shall be performed with mouse and/or a minimum number of function keys and cursor keys. The function keys shall have different meanings depending on the operation. The operator shall see the relevant meanings as function tests displayed in the command field (i.e. operator prompting). For control actions, the switchgear (i.e. circuit breaker etc.) requested shall be selectable on the display by means of the cursor keys. The switching element selected shall then appear on the background that shall be flashing in a different color. The operator prompting shall distinguish between:-

- Prompting of indications e.g. fault indications in the switchgear, and

- prompting of operational sequences e.g. execution of switching operations

The summary information displayed in the message field shall give a rapid display of alarm/message of the system in which a fault has occurred and alarm annunciation lists in which the fault is described more fully.

Each operational sequence shall be divided into single operation steps which are initiated by means of the function keys/WINDOW command by mouse. Operator prompting shall be designed in such a manner that only the permissible keys are available in the command field related to the specific operation step. Only those switching elements shall be accessed for which control actions are possible. If the operation step is rejected by the system, the operator prompting shall be supported by additional comments in the message field. The operation status shall be reset to the corresponding preceding step in the operation sequence by pressing one of the function keys. All operations shall be verified. Incorrect operations shall be indicated by comments in the message field and must not be executed.

The offer shall include a comprehensive description of the system. The above operation shall also be possible via WINDOWS based system by mouse.

8.0 POWER SUPPLY

Power for the substation automation system shall be derived from substation 220V DC system.

2No.s of Inverter of minimum 2KVA capacity shall be provided for servers, gateways station HMI disturbance recorder evaluation unit and its peripheral devices e.g. printer etc. In the event of Power failure, necessary safeguard software shall be built for proper shutdown. Inverter shall be connected to 220V DC independent source and should be used to drive 1No. each server/HMI/Gateway so that in case any failure of DC power supply system is not affected.

9.0 DOCUMENTATION

The following documents shall be submitted for employer's approval during detailed engineering:

(a) System Architecture Drawing
(b) Hardware Specification
(c) Functional Design Document
(d) Clear procedure describing how to add an IED/bay/diameter in future covering all major supplier

The following documentation to be provided for the system in the course of the project shall be consistent, CAD supported, and of similar look/feel. All CAD drawings to be provide in "dxf" format.

* List of Drawings
* Substation automation system architecture
* Block Diagram
* Guaranteed technical parameters, Functional Design Specification and Guaranteed availability and reliability
* Calculation for power supply dimensioning
* I/O Signal lists
* Schematic diagrams
* List of Apparatus
* List of Labels
* Logic Diagram (hardware & software)
* **Switchyard Panel Room** layout drawing
* Control Room Lay-out
* Test Specification for Factory Acceptance Test (FAT)
* Product Manuals
* Assembly Drawing
* Operator's Manual
* Complete documentation of implemented protocols between various elements
* Listing of software and loadable in CD ROM
* Other documents as may be required during detailed engineering

Two sets of hard copy and Four sets of CD ROM containing all the as built documents/drawings shall be provided.

10.0 TRAINING, SUPPORT SERVICES, MAINTENANCE AND SPARES

10.1 Training

Contractor personnel who are experienced instructors and who speak understandable English shall conduct training. The contractor shall arrange on its own cost all hardware training platform required for successful training and understanding in Nepal. The Contractor shall provide all necessary training material. Each trainee shall receive individual copies of all technical manuals and all other documents used for training. These materials shall be sent to Employer at least two months before the scheduled commencement of the particular training course. Class materials, including the documents sent before the training courses as well as class handouts, shall become the property of Employer. Employer reserves the right to copy such materials, but for in-house training and use only. Hands-on training shall utilize equipment identical to that being supplied to Employer.

The Contractor shall quote training prices as indicated in SCHEDULES OF RATES AND PRICES.

The schedule, location, and detailed contents of each course will be finalized during Employer and Contractor discussions.

10.2 Computer System Hardware Course

A computer system hardware course shall be offered, but at the system level only. The training course shall be designed to give Employer hardware personnel sufficient knowledge of the overall design and operation of the system so that they can correct obvious problems, configure the hardware, perform preventive maintenance, run diagnostic programs, and communicate with contract maintenance personnel. The following subjects shall be covered:

(a) System Hardware Overview: Configuration of the system hardware.

(b) Equipment Maintenance: Basic theory of operation, maintenance techniques and diagnostic procedures for each element of the computer system, e.g., processors, auxiliary memories, LANs, routers and printers. Configuration of all the hardware equipments.

(c) System Expansion: Techniques and procedures to expand and add equipment such as loggers, monitors, and communication channels.

(d) System Maintenance: Theory of operation and maintenance of the redundant hardware configuration, failover hardware, configuration control panels, and failover switches. Maintenance of protective devices and power supplies.

(e) Subsystem Maintenance: Theory of design and operation, maintenance techniques and practices, diagnostic procedures, and (where applicable) expansion techniques and procedures. Classes shall include hands-on training for the specific subsystems that are part of Employer's equipment or part of similarly designed and configured subsystems. All interfaces to the computing equipment shall be taught in detail.

(f) Operational Training: Practical training on preventive and corrective maintenance of all equipment, including use of special tools and instruments. This training shall be provided on Employer equipment, or on similarly configured systems.

10.3 Computer System Software Course

The Contractor shall provide a computer system software course that covers the following subjects:

(a) System Programming: Including all applicable programming languages and all stand-alone service and utility packages provided with the system. An introduction to software architecture, Effect of tuning parameters (OS software, Network software, database software etc.) on the performance of the system.

(b) Operating System: Including the user aspects of the operating system, such as program loading and integrating procedures; scheduling, management, service, and utility functions; and system expansion techniques and procedures

(c) System Initialization and Failover: Including design, theory of operation, and practice

(d) Diagnostics: Including the execution of diagnostic procedures and the interpretation of diagnostic outputs,

(e) Software Documentation: Orientation in the organization and use of system software documentation.

(f) Hands-on Training: One week, with allocated computer time for trainee performance of unstructured exercises and with the course instructor available for assistance as necessary.

10.4 Application Software Course

The Contractor shall provide a comprehensive application software courses covering all applications including the database and display building course. The training shall include:

(a) Overview: Block diagrams of the application software and data flows. Programming standards and program interface conventions.

(b) Application Functions: Functional capabilities, design, and major algorithms. Associated maintenance and expansion techniques.

(c) Software Development: Techniques and conventions to be used for the preparation and integration of new software functions.

(d) Software Generation: Generation of application software from source code and associated software configuration control procedures.

(e) Software Documentation: Orientation in the organization and use of functional and detailed design documentation and of programmer and user manuals.

(f) Hands-on Training: One week, with allocated computer time for trainee performance of unstructured exercises and with the course instructor available for assistance as necessary.

10.5 Requirement of training:

The contractor shall provide training for OWNER'S personnel comprehensively covering following courses.

S. No.	Name of Course
1	Computer System Hardware
2	Computer System Software
3	Application Software

11.0 Maintenance

11.1 Maintenance Responsibility during the Guaranteed Availability Period.

During Guaranteed Availability Period, the Contractor shall take continual actions to ensure the guaranteed availability and shall make available all the necessary resources such as specialist personnel, spare parts, tools, test devices etc. for replacement or repair of all defective parts and shall have prime responsibility for keeping the system operational. **During guarantee period as specified in tender document, contractor shall arrange bi-monthly visit of their representative to site to review the performance of system and in case any defect/shortcoming etc. is observed during the period, the same shall be set right by the contractor within 15 days.**

12.0 RELIABILITY AND AVAILABILITY

The SAS shall be designed so that the failure of any single component, processor, or device shall not render the system unavailable. The SAS shall be designed to satisfy the very high demands for reliability and availability concerning:

- Mechanical and electrical design
- Security against electromagnetic interference (EMI)
- High quality components and boards
- Modular, well-tested hardware
- Thoroughly developed and tested modular software
- Easy-to-understand programming language for application programming
- Detailed graphical documentation and application software
- Built-in supervision and diagnostic functions
- Security
  - Experience of security requirements
  - Process know-how
  - Select before execute at operation
  - Process status representation as double indications
- Distributed solution
- Independent units connected to the local area network
- Back-up functions
- Panel design appropriate to the harsh electrical environment and ambient conditions
- Panel grounding immune against transient ground potential rise

Outage terms

1) Outage

The state in which substation automation system or a unit of SAS is unavailable for Normal Operation as defined in the clause 7.1 due to an event directly related to the SAS or unit of SAS. In the event, the owner has taken any equipment/ system other than Sub-station Automation System for schedule/forced maintenance, the consequent outage to SAS shall not be considered as outage for the purpose of availability.

2) Actual outage duration (AOD)

The time elapsed in hours between the start and the end of an outage. The time shall be counted to the nearest $1/4^{th}$ of an hour. Time less than $1/4^{th}$ of an hour shall be counted as having duration of $1/4^{th}$ of an hour.

3) Period Hours (PH)

The number of hours in the reporting period. In a full year the period hour are 8760h (8784h for a leap year).

4) Actual Outage hours (AOH)

The sum of actual outage duration within the reporting period

AOH = ∑ AOD

5) Availability:

Each SAS shall have a total availability of 99.98 % i.e. the ratio of total time duration minus the actual outage duration to total time duration.

12.1 Guarantees Required

The availability for the complete SAS shall be guaranteed by the Contractor. Bidder shall include in their offer the detailed calculation for the availability. The contractor shall demonstrate their availability guaranteed by conducting the availability test on the total sub-station automation system as a whole after commissioning of total Sub-station Automation system. The test shall verify the reliability and integrity of all sub-systems. Under these conditions the test shall establish an overall availability of 99.98%. After the lapse of 1000 Hours of cumulative test time, test records shall be examined to determine the conformance with availability criterion. In case of any outage during the availability test, the contractor shall rectify the problem and after rectification, the 1000 Hours period start after such rectification. If test object has not been met the test shall continue until the specified availability is achieved.

The contractor has to establish the availability in a maximum period of three months from the date of commencement of the availability test.

After the satisfactory conclusion of test both contractor and employer shall mutually agree to the test results and if these results satisfy the availability criterion, the test is considered to be completed successfully. After that the system shall be taken over by the employer and then the guarantee period shall start.

13.0 Spares

13.1 Consumables:

All consumables such as paper, cartridges shall be supplied by the contractor till the SAS is taken over by the owner.

13.2 Availability Spares:

In addition to mandatory spares as listed in Chapters on project for SAS, the bidder is required to list the spares, which may be required for ensuring the guaranteed availability during the guaranteed availability period. The final list of spares shall form part of scope of supply and accordingly the price thereof shall be quoted by the bidder and shall be considered in the evaluation of the bids. During the guaranteed availability period, the spare parts supplied by the Contractor shall be made available to the Contractor for usage subject to replenishment at the earliest. Thus, at the end of availability period the inventory of spares with the Employer shall be fully replenished by the Contractor. However, any additional spares required to meet the availability of the system (which are not a part of the above spares supplied by the Contractor) would have to be supplied immediately by the Contractor free of cost to the Employer.

14.0 LIST OF EQUIPMENTS

Quantity of equipments shall be decided by bidder in order to achieve guaranteed reliability and availability as declared by bidder.

i) Station HMI
ii) Redundant Station HMI (in Hot-stand by mode)
iii) Bay level units along with bay mimic as detailed in Chapter 1 – Project Specification Requirement.
iv) Bay Level Unit for Auxiliary system (as per requirement)
v) Disturbance Recorder Work Station(Maintenance HMI)
vi) Colour Laser Printer – 1 No. (For Reports & Disturbance records)
vii) Dot matrix printers - (one each for Alarms and log sheets)
viii) All interface equipment for gateway to RCC and RSCC
ix) Communication infrastructure between Bay level units, Station HMI, Printers, gateways, redundant LAN etc. as required
x) Remote workstation including HMI and along with one printer
xi) Modems as per requirement.
xii) Any other equipment as necessary.

Annexure-I

List of Analogue and Digital Inputs

Basic Monitoring requirements are:

- Switchgear status indication
- Measurements (U, I, P, Q, f)
- Event
- Alarm
- Winding temperature of transformers & reactors
- ambient temperature
- Status and display of 400V LT system, 220V & 48V DC system
- Status of display of Fire protection system and Air conditioning system.
- Acquisition of all counters in PLCC panels through potential free contacts from PLCC or independently by counting the receive/send commands.
- Acquisition of alarm and fault record from protection relays
- Disturbance records
- Monitoring the state of batteries by displaying DC voltage, charging current and load current etc.
- Tap-position of Transformer

List of Inputs

The list of input for typical bays is as below:-

Analogue inputs

i) For line
Current R phase
Y phase
B phase
Voltage R-Y phase
Y-B phase
B-R phase

ii) For transformer/reactor
Current R phase
Y phase
B phase
WTI (for transformer and reactor)
Tap position (for transformer only)

iii) For TBC and bus coupler

Current R phase

Y phase
B phase

iv) Common

a) Voltage for Bus-I, Bus-II and Transfer bus wherever applicable

Voltage R-Y phase
Y-B phase
B-R phase

b) Frequency for Bus-I and Bus-II

c) Ambient temperature (switchyard)

d) Switchyard Panel Room Temperature.

e) LT system

i) Voltage R-Y, Y-B, B-R of Main Switch Board section-I
ii) Voltage R-Y, Y-B, B-R of Main Switch Board section-II
iii) Voltage R-Y, Y-B, B-R of Diesel Generator
iv) Current from LT transformer-I
v) Current from LT transformer-II
vi) Current from Diesel Generator
vii) Voltage of 220V DCDB-I
viii) Voltage of 220V DCDB-II
ix) Current from 220V Battery set-I
x) Current from 220V Battery set-II
xi) Current from 220V Battery charger-I
xii) Current from 220V Battery charger-I
xiii) Voltage of 48V DCDB-I
xiv) Voltage of 48V DCDB-II
xv) Current from 48V Battery set-I
xvi) Current from 48V Battery set-II
xvii) Current from 48V Battery charger-I
xviii) Current from 48V Battery charger-I

Digital Inputs

The list of input for various bays/SYSTEM is as follows:

1. Line bays

i) Status of each pole of CB.
ii) Status of Isolator, Earth switch
iii) CB trouble
iv) CB operation/closing lockout
v) Pole discrepancy optd
vi) Trip coil faulty
vii) LBB optd
viii) Bus bar protn trip relay optd
ix) Main bkr auto recloser operated
x) Tie/transfer auto recloser operated
xi) A/r lockout
xii) Tie/transfer bkr a/r lockout

xiii) Direct trip-I/II sent
xiv) Direct trip-I/II received
xv) Main I/II blocking
xvi) Main I/II-Inter trip send
xvii) Main I/II-Inter trip received
xviii) O/V STAGE – I operated
xix) O/V STAGE – II operated
xx) FAULT LOCATOR FAULTY
xxi) MAIN-I/II CVT FUSE FAIL
xxii) MAIN-I PROTN TRIP
xxiii) MAIN-II PROTN TRIP
xxiv) MAIN-I PSB ALARM
xxv) MAIN-I SOTF TRIP
xxvi) MAIN-I R-PH TRIP
xxvii) MAIN-I Y-PH TRIP
xxviii) MAIN-I B-PH TRIP
xxix) MAIN-I START
xxx) MAIN-I/II Carrier aided trip
xxxi) MAIN-I/II fault in reverse direction
xxxii) MAIN-I/II ZONE-2 TRIP
xxxiii) MAIN-I/II ZONE-3 TRIP
xxxiv) MAIN-I/II weak end infeed optd
xxxv) MAIN-II PSB alarm
xxxvi) MAIN-II SOTF TRIP
xxxvii) MAIN-II R-PH TRIP
xxxviii) MAIN-II Y-PH TRIP
xxxix) MAIN-II B-PH TRIP
xl) MAIN-II start
xli) MAIN-II aided trip
xlii) MAIN-I/II fault in reverse direction
xliii) Back-up o/c optd
xliv) Back-up e/f optd
xlv) 220V DC-I/II source fail
xlvi) SPEECH CHANNEL FAIL
xlvii) PLCC Protection Channel-I FAIL
xlviii) PLCC Protection Channel-II FAIL

2. **Transformer bays**

i) Status of each pole of CB, Isolator, Earth switch
ii) CB trouble
iii) CB operation/closing lockout
iv) Pole discrepancy optd
v) Trip coil faulty
vi) LBB optd
vii) Bus bar protn trip relay optd
viii) REF OPTD
ix) DIF OPTD
x) OVERFLUX ALARM (MV)
xi) OVERFLUX TRIP (MV)
xii) OVERFLUX ALARM (HV)

xiii) OVERFLUX TRIP (HV)
xiv) HV BUS CVT ½ FUSE FAIL
xv) MV BUS CVT ½ FUSE FAIL
xvi) OTI ALARM/TRIP
xvii) PRD OPTD
xviii) OVERLOAD ALARM
xix) BUCHOLZ TRIP
xx) BUCHOLZ ALARM
xxi) OLTC BUCHOLZ ALARM
xxii) OLTC BUCHOLZ TRIP
xxiii) OIL LOW ALARM
xxiv) back-up o/c (HV) optd
xxv) back-up e/f (HV)optd
xxvi) 220v DC-I/II source fail
xxvii) TAP MISMATCH
xxviii) GR-A PROTN OPTD
xxix) GR-B PROTN OPTD
xxx) back-up o/c (MV) optd
xxxi) back-up e/f (MV)optd

3. **Transformer bays**

i) Status of each pole of CB, Isolator, Earth switch
ii) CB trouble
iii) CB operation/closing lockout
iv) Pole discrepancy optd
v) Trip coil faulty
vi) LBB optd
vii) Bus bar protn trip relay optd
viii) REF OPTD
ix) DIF OPTD
x) HV BUS CVT ½ FUSE FAIL
xi) OTI ALARM/TRIP
xii) PRD OPTD
xiii) BUCHOLZ TRIP
xiv) BUCHOLZ ALARM
xv) OIL LOW ALARM
xvi) Back-up impedance relay
xvii) 220v DC-I/II source fail
xviii) GR-A PROTN OPTD
xix) GR-B PROTN OPTD

4. Line/Bus Reactor bays (as applicable):

i) Status of each pole of CB, Isolator, Earth switch
ii) CB trouble
iii) CB operation/closing lockout
iv) Pole discrepancy optd
v) Trip coil faulty

vi) LBB optd
vii) Bus bar protn trip relay optd
viii) REF OPTD
ix) DIF OPTD
x) Line/ BUS CVT ½ FUSE FAIL
xi) OTI ALARM/TRIP
xii) PRD OPTD
xiii) BUCHOLZ TRIP
xiv) BUCHOLZ ALARM
xv) OIL LOW ALARM
xvi) Back-up impedance relay
xvii) 220V DC-I/II source fail
xviii) GR-A PROTN OPTD
xix) GR-B PROTN OPTD

5 **Bus bar Protection**

i) Bus bar main-I trip
ii) Bus bar main-II trip
iii) Bus bar zone-I CT open
iv) Bus bar zone-II CT open
v) Bus transfer CT sup. Optd
vi) Bus transfer bus bar protn optd
vii) Bus protection relay fail

6. **Auxiliary system**

i) Incomer-I On/Off
ii) Incomer-II On/Off
iii) 400V Bus-I/II U/V
iv) 400V bus coupler breaker on/off
v) LT transformer-I Bunchholz Alarm & trip
vi) LT transformer-II Buchloz Alarm & trip
vii) LT transformer-I WTI Alarm & trip
viii) LT transformer-II WTI Alarm & trip
ix) LT transformer-I OTI Alarm & trip
x) LT transformer-II OTI Alarm & trip
xi) PLCC exchange fail
xii) Time sync. Signal absent
xiii) Alarm/trip signals as listed in Chapter: Battery and Battery charger
xiv) 220V DC-I earth fault
xv) 220V DC-II earth fault
xvi) Alarm/trip signals as listed in Chapter: Fire protection system

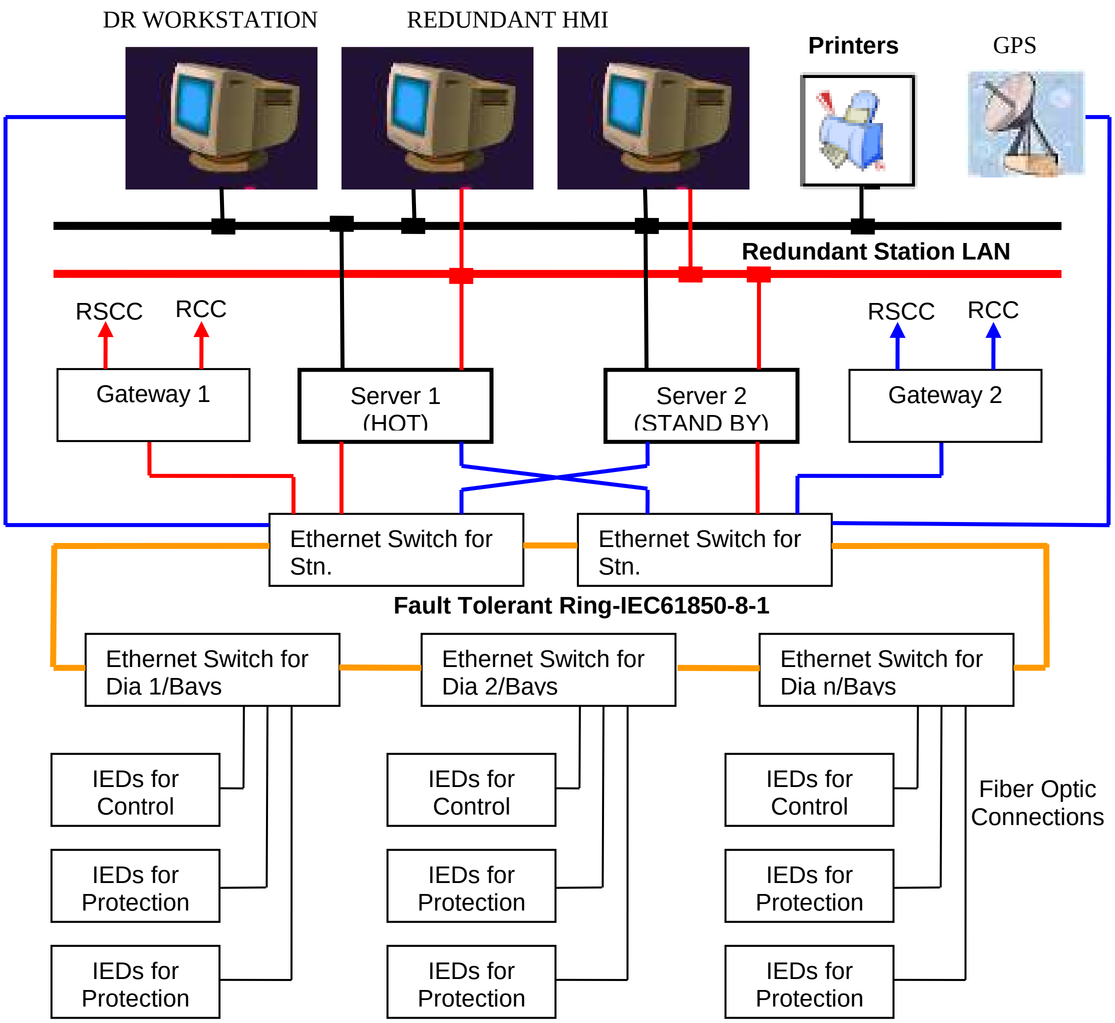
7. Switchyard Panel Room:

i) AC Compressor 1 ON/OFF
ii) AC Compressor 2 ON/OFF
iii) Fire Detection 1 ON/OFF
iv) Fire Detection 2 On/OFF
v) Switchyard Panel Room Temperature High Alarm

The exact number and description of digital inputs shall be as per detailed engineering requirement Apart from the above mentioned digital inputs, minimum of 200 inputs shall be kept for future use.

Annexure-II

Typical Architectural Drawing of Substation Automation System



Note:

1. The redundant managed bus shall be realized by high speed optical bus using industrial grade components and shall be as per IEC 61850.
2. Inside the sub-station, all connections shall be realized as per IEC 61850 protocol.
3. For gateway, it shall communicate with Remote Supervisory Control Centre (RSCC) on IEC 60870-5-101 protocol.
4. The printer as required shall be connected to station bus directly and can be managed either from station HMI, HMI view node or disturbance recorder work station.
5. The above layout is typical. However if any contractor offers slightly modified architecture based on their standard practice without compromising the working, the same shall be subject to approval during detailed engineering.

Annexure-III

List of IO Points to be transmitted to LDC Kathmandu

a) MW and MVAR for all lines , transformers, reactors and Capacitors
b) Voltage of all buses
c) Frequency of 400kV/220 kV Bus
d) All Breakers
e) All isolators
f) Tap Position for all transformers
g) Master protection signal for all feeders, transformers Units and Bus Bar
h) Loss of Voltage signal for Bus bar
i) All the points identified in point (e), (h) and (i) above as GPS Time stamped.
j) Temperature value per substation.
k) Any other point decided during detailed engineering and deem to be included in the present scope of the contract.

CHAPTER 19: TELECOMMUNICATION EQUIPMENTS

Section I: Technical Specification for Fibre Optic Based Communication Equipments

1.1 General

The scope covers design, engineering, manufacture and testing at manufacturer's works before dispatch, packing and forwarding, transportation, insurance, handling, delivering at site, proper storage at site, factory training, site training, supervision for erection testing and commissioning, installation of Fiber Optics Based Communication equipments which includes Fibre Optic Terminal and Multiplexer equipment which includes all materials, accessories and fittings, erection & maintenance tools & tackles, mandatory spares as detailed in this specification for 400 kV Substation in Hetauda (Makawanpur District), Inaruwa (Sunsari District) and integration of communication network from Hetauda Substation to LDC Kathmandu for Inaruwa-Dhalkebar-Hetauda- LDC Kathmandu Link in Nepal. The technical specification includes installing communication System, telephone system, teleprotection and interface cards to interconnect with SCADA and CCTV equipment for the efficient supervision, control, operation and maintenance of the transmission system. Optical fiber communication link with its associated terminal equipments are required at 400/220 kV Substation in in Hetauda (Makawanpur District).

This section describes the Fiber Optic Communication equipment characteristics for communication system to be installed under the project. The sub-systems addressed within this section are:

(1) Fiber Optic Transmission System (FOTS)
(2) DDF and Cabling
(3) Craft Terminal based Network Management System (NMS)
(4) FO Approach Cable
(5) FODP

The equipment supplied shall support existing communication network for Power system operational requirements.

The security related requirements of the equipment shall be as per DoT (Department of Telecommunication) guidelines and all similar security requirements as amended by DoT on time to time basis shall be followed/complied by the vendor at no additional cost to Employer till the implementation of the project.

The manufacturer shall allow the Employer and/or its designated agencies to inspect the hardware, software, design, development, manufacturing, facility and supply chain and subject all software to a security /threat check any time during the supplies of equipment

The contractor shall ensure that the supplied equipments have been got tested as per relevant International Security Standards e.g. IT and IT related elements against ISO/IEC

15408 standards, for Information Security Management System against ISO 27000 series Standards, Telecom and Telecom related elements against 3GPP security standards, 3GPP2 security standards etc. from any international agency/ labs of the standards e.g. Common Criteria Labs in case of ISO/IEC 15408 standards.

In case of any deliberate attempt for a security breach at the time of procurement or at a later stage after deployment/installation of the equipment or during maintenance, liability and criminal proceedings can be initiated against the Contractor as per guidelines of DoT and any other Government department.

The primary function of the equipment is to provide a highly reliable voice and data communication system for grid operation in support of the SCADA/EMS, RTUs, Teleprotection & PMUs and for new technological requirements of Power System Operation such as Special Protection Scheme, Grid Security Expert System, Load Management, Advanced Protection System & Substation Automation System. A brief summary of the system requirements is as follows:

(a) High speed E1 channel support
(b) 64kbps & nx64kbps data channel support as required
(c) Low speed (300 -1200 bps) data channel support as required
(d) Voice (2 wires, 4 wires) channel support and integration with Employer's/LDC's EPABX system. The details of EPABX System shall be provided during detailed engineering.
(e) Data transport supporting Network Management channels
(f) The connectivity envisaged between Substation and Control Centre over TCP-IP using Ethernet interface for various services of data and voice such as for PMUs, RTUs, VOIP etc.

2.1 Fibre Optic Transmission System

2.1.1 General Network Characteristics

The SDH node shall be used for interconnection of terminal Substation to the fibre optic network and shall be based on the Synchronous Digital Hierarchy (SDH) having bit rate of STM-4/16 as specified in BPS.

The FO Communication equipment to be supplied shall be a complete SDH node (add- drop multiplexer) providing all the features e.g. protection and per formance monitoring. This will be used for delivering E1 as per ITU-T G.703 and Giga/fast Ethernet services except repeater stations. In case other interface such as AsynchronousSub-channel data card (RS232/V.24/V.28), Synchronous da ta card (V.35/X.21), 2 wire voice channel card or 4 wire (E&M) voice channel card as required, shall be supplied either in the same equipment or as independent PDH equipment.

The Contractor shall supply the equipment as per the technical specification. The deliverables shall include all installation materials necessary for successful installation and commissioning of the equipment viz. AC & DC power supply cabling, Krone type/120Ω balanced type Digital Distribution Frame (DDF) in enclosure, optical patch cords for FODP-to-equipment and equipment-to-equipment connection, optical attenuator (5dB/10dB), flexible conduits etc. as per site requirement. Additionally one (1) pair of optical patch cord per SDH node will be supplied as spare. User Manual, System Guide shall be delivered with each equipment. The Contractor shall provide all required minor civil works necessary for full connectivity as required.

Equipment redundancy and Automatic Protection Schemes (APS) are specified in the Table 1. The failure of one element shall not prevent the use of any other that has not failed.

Table 1
Equipment Redundancy Requirements Summary

Fiber Optic transmission Equipment :	
SDH equipment	
Power Supply & Converters ------------------------------	1:1 APS or distributed power supply
Common Control* Cards -----------------------------------	1:1 APS
*** = Common control cards which are essentially required for operation of the equipment.**	

The offered equipment shall support automatic switchover function between the redundant modules and all required modules and hardware to support the automatic switch over shall be provided by the Contractor.

At any digital signal level, reapplication of a lost signal shall result in automatic resynchronization and full restoration to normal operation without manual intervention. All alarms incident to the signal failure, shall be automatically cleared at the equipment, rack and monitoring levels and normal operation indications restored and reported if applicable.

The offered transmission equipment (SDH node) shall support optical link of at least 250 Km for STM-4 and 225Km for STM-16 without any repeater station in between. If required, wavelength translator/ optical amplifier shall be provided by the contractor.

2.1.2 Features of Transmission Equipment

a) Aggregate interface shall be STM-4/16, with three (3)/Five (5) MSP protected directions. If bidder is offering equipment with multifunction cards such as cross- connect or control card with optical interface/SFP or tributary interface, such type of multifunction card shall be considered as Common control card and shall be the part of base equipment. In case optical interface/SFP is embedded with control card, the adequate number of optical interface/SFPs shall be offered to meet the redundancy requirements of the specifications. Further, main and protection channel shall be terminated on separate cards. Aggregate interface of STM-4/16 shall have FC/PC or SC or LC connector.

b) All software and hardware shall support IPv4 and IPv6 simultaneously (dual stack).

c) SDH equipment shall support dual power feed with redundancies for Power supply unit and Control unit in each rack.
d) Minimum 16 nos. x 2 Mbit/s per card, 120Ω tributary interface compliant to ITU-T G.703, G.704 with suitable connector
e) Ethernet interface shall have minimum 8 nos. per card of RJ-45 port for ingress and egress of Ethernet data (Ethernet over SDH) at 10/100/1000 Base-T speeds/standards (ITU-T G.7041GFP capsulation). Ethernet shall support LCAS feature. It shall support full throughput upto 1000 Mbps on Ethernet port by virtual concatenation of requisite no. of VC-12.There shall be the provision of "Auto Negotiation" and "Flow control" Enabling/disabling through NMS of the system. Also there shall be provision of configuring the equipment for unrestricted nxVC12 bandwidth (upto 1000Mbps). The Ethernet interface shall support VLAN (IEEE 802.IP/Q), spanning tree (IEEE 802.ID) quality of service. The protection scheme for Ethernet traffic should be VLAN/ERPS based.
f) Services channel shall be provided as a function of the SDH equipment and shall be equipped with Service Channel Muldems that shall provide at a minimum: One voice channel (order wire) with analog interface (0.3 to 3.4 kHz) and one data channel. There shall be a facility to extend the line system order-wire to any other system or exchange lines.
g) ADM configuration for traffic protection by using SNCP & MSP.
h) Synchronization: The synchronization of the FO equipment shall be as per ITU-T standard G.811. The substation GPS can be used for extending synchronization to equipment. Alternately existing network Master Clock can be used for synchronization.

i) ISM (In Service Monitoring) circuitry shall be provided as a function of the SDH equipment. Local visual alarm indicators shall be provided on the equipment, as a rack summary alarm panel. Alarms shall be as per ITU-T Standards G.774, G.783 and G.784.
j) Downloading of software shall be possible from remote.
k) Shall have Embedded Communication Channel (ECC), ports (Ethernet/RS232) for craft terminal and management interface and shall support DCC pass trough.
l) DCN implementation through protected VC12. Support DCN grooming in VC12.
m) Pre-connectorised Optical patch cords shall be of G.625D fibre. The Patch cord return loss shall be equal to or better than 40 dB and insertion loss equal to or less than 0.5 dB. Fiber jumpers shall be of sufficient lengths as to provide at least 0.5m of service loop.
n) Shall be operated with -48 V DC Power Supply. DC power interface shall be suitable to work on a nominal voltage of -48V ± 20%.
o) Compact design suitable for installation in 19" rack.

2.1.2.1 Network Monitoring (Craft Terminal based)

a) Manageable by Craft Terminal programme. It shall support performance monitoring, remote software upgrade, configuration management from remote as well as local craft terminal. The craft terminal shall have minimum configuration of 2.4 GHz, 2 GB RAM, 256 MB Video Graphics Memory, DVD RW drive, 160 GB Hard Disk Drive, keyboard, mouse/trackball etc., serial/USB (2.0) ports to accommodate printers, IEEE 802.11a/b/g wireless LAN, Bluetooth, Internal/external Data/Fax modem and a battery back-up of at least 3 hours. VDUs shall be 15" TFT active matrix color LCD with a minimum resolution of 1024 X 768.
b) Local Craft Terminal will be provided with requisite software for performing all element level management functions viz. configuration management, fault management, performance management etc.
c) Provision shall be there in the Local Craft Terminal for integration with full fledged NMS server .

2.1.3 Optical Link Budget Calculations

The fibre optic link budget calculations shall be calculated based upon the following criteria:

1. Fibre attenuation: The fibre attenuation shall be taken to be the guaranteed maximum fibre attenuation i.e. 0.21 dB/Km @1550nm and 0.35 dB/km @1310nm.

2. Splice loss: Minimum 0.05 dB per splice. One splice shall be considered for every 3 kms.

3. Connector losses: Losses due to connectors shall be considered to be minimum 1.0 dB per link.

4. Equipment Parameters: The equipment parameters to be considered for link budget calculations shall be the guaranteed "End of Life (EOL)" parameters. In case, the End of Life parameters are not specified for the SDH equipment, an End of Life Margin of at least 2 dB shall be considered and a similar margin shall be considered for optical amplifiers.

5. Optical path Penalty: An optical path penalty of at least 1 dB shall be considered to account for total degradations due to reflections, inter symbol interference, mode partition noise and laser chirp.

6. Maintenance Margin: A maintenance margin of at least 2.5 dB/100Km shall be kept towards cabling, repair splicing, cable ageing and temperature variations etc.

7. Other losses: Other losses, if any required specifically for system to be supplied shall also be suitably considered.

8. Dispersion: The fibre dispersion shall be taken to be the guaranteed maximum dispersion i.e. 18 ps/nm.Km @1550 nm & 3.5 ps/nm.km @ 1310 nm for DWSM fibres.

9. Bit Error Rate: The link budget calculations shall be done for a BER of 10-10.

The bidders shall determine the total link loss based on the above parameters and shall submit the system design (including link budget calculations) for each fibre optic link during detailed engineering.

For finalising the FOTS system design & BOQ, above methodology shall be adopted taking into account fibre attenuation, dispersion and splice loss determined during the detailed engineering. Accordingly, additions and deletions from the contract shall be carried out based on unit rates indicated in the contract.

2.2 Fibre Optic Approach Cable

For purposes of this specification, a fibre optic approach cable is defined as the Armoured underground fibre optic cable required to connect Overhead Fibre Optic Cable (OPGW) between the final in line splice enclosure on the gantry / tower forming the termination of the fibre cable on the power line and the Fibre Optic Distribution Panel (FODP) installed within the building. The estimated fibre optic approach cabling length requirements are indicated in the appendices. However, the Contractor shall supply & install the optical fibre approach cable as required based on detailed site survey to be carried out by the Contractor during the project execution and the

Contract price shall be adjusted accordingly. Approach Cable shall consist G.652D DWSM Fibers.

2.2.1 Basic Construction

The cable shall be suitable for direct burial, laying in trenches & PVC/Hume ducts, laying under false flooring and on indoor or outdoor cable raceways. The jacket shall conform to ASTM D1248 for density.

2.2.2 Optical Electrical and Mechanical Requirements

Approach cable shall contain fibres with identical optical/ physical characteristics as those in the OPGW cables. The cable core shall comprise of tensile strength member(s), fibre support/bedding structure, core wrap/bedding, and an overall impervious jacket.

2.2.3 Installation Of Approach Cable

The existing cable trenches/ cable raceways proposed to be used shall be identified in the survey report. The Contractor shall make its best effort to route the cable through the existing available cable trenches. Where suitable existing cable trenches are not available, suitable alternatives shall be provided after Employer approval.

Suitable provisions shall be made by the Contractor to ensure adequate safety earthing and insulated protection for the approach cable.

All required fittings, supports, accessories, ducts, inner ducts, conduits, risers and any item not specially mentioned but required for laying and installation of approach cables shall be supplied and installed by the Contractor.

2.3 Optical Fibre Termination and Splicing

Optical fibre terminations shall be done in Fibre Optic Distribution Panels (FODP) designed to provide protection for fibre splicing of preconnectorized pigtails and to accommodate connectorized termination and coupling of the fibre cables. The Contractor shall provide rack /wall mounted Fibre Optic Distribution Panels (FODPs) sized as indicated in the appendices and shall terminate the fibre optic cabling up to the FODPs. The location of FODP rack shall be fixed by the Contractor, with the Employer‟s approval.

2.3.1 Fibre Optic Distribution Panel

At each location requiring the termination of at least one fibre pair within a cable, all fibres within that cable shall be connectorized and terminated in Fibre Optic Distribution Panels in a manner consistent with the following:

(a) All fibre optic terminations shall be housed using FODPs provisioned with splice organizers and splice trays. All fibres within a cable shall be fusion spliced to preconnectorized pigtails and fitted to the "Back-side" of the provided fibre optic couplings.

(b) FODPs shall be suitable for use with each of the cable types provided as part of this contract. FODPs shall accommodate pass-through splicing and fibre terminations.

(c) FODPs for indoor use shall be supplied in suitable cabinets/racks with locking arrangement.

(d) The FODP shall be of corrosion resistant, robust construction and shall allow both top or bottom entry for access to the splice trays. Ground lugs shall be provided on all FODPs and the Contractor shall ensure that all FODPs are properly grounded. The FODP shall meet or exceed ingress protection class IP55 specifications.

(e) Flexible protection shall be provided to the patch cord bunches going out from FODP
cabinet to other equipment cabinet.

3.1 Environmental, EMI, Power Supply Cabling and Earthing Requirements

- Equipment shall operate in accordance with the Environmental Operating limits as shown in Table-2.

Table -2
Environmental Operating Limits

Temperature Range: **Specification** **Operation without damage** **Shipping/storage**	(Un Controlled Environment) 0 to 45°C -10 to 55°C -40 to 60°C
Relative Humidity, non-condensing	Upto 90%
Elevation: Operating **Non-operating**	to 3,000 m to 10,000 m

- Equipment shall be properly shielded against radiated emissions at each location.

- Power Distribution and Protection: Power supplies/converters for communications equipment shall use -48Vdc uninterrupted primary source power. The Employer will furnish only one power source. Contractor shall provide required distribution panels, circuit breakers, appropriate panel disconnects and all cabling, fusing, switching required. Distribution Panel feeders, Panel Disconnects, distribution panels and circuit breakers shall be sized and equipped to support at least 100% expanded load requirements.

- Contractor shall provide equipment and rack safety earthing in full compliance with EMI/EMC requirements as per relevant international standards.
- Equipment cabinet (enclosure) shall be designed 19 inch, free standing but shall be mounted on the floor. The dimensions of the cabinet shall be minimum 2200mmx600mmx600mm. All doors and removable panels shall be fitted with long life synthetic gaskets Neoprene/EPDM. All panels shall be fabricated from minimum 2.0mm thickness steel sheet. However, for racks with load bearing Aluminium extrusion frame, door panels and side panels may be fabricated from minimum 1.6mm thickness steel sheet and the top & bottom panels shall be fabricated from minimum 2.0mm thickness steel sheet. The exterior and interior colour of the paint shall be RAL 7032. Equipment cabinet (enclosure) shall be dust and moisture proof as per IP41 specification or better (supporting certificates/documents shall be submitted during detailed engineering).
- The Contractor shall provide all required minor civil works necessary for full connectivity as
- required in the Contractor's scope of work.
- Any other miscellaneous items which may be required for successful interfacing for establishment of end-to-end communication is deemed to be included in the scope of the Contractor.

4.1 TESTING

All materials furnished and all work performed under this Contract shall be inspected and tested. The entire cost of testing for factory & site acceptance, routine tests, production tests and other test during manufacture & site activities specified herein shall be treated as included in the quoted unit price of materials, except for the expenses of Inspector/Employer's representative. All tests shall be witnessed by the Employer and/or its authorized representative (hereinafter referred to as the Employer) unless the Employer authorizes testing to proceed without witness.

"Type Tests" shall be defined as those tests which are to be carried out to prove the design, process of manufacture and general conformity of the materials to this Specification. All equipment being supplied shall conform to type tests as per Annexure-I of technical specification. The test reports submitted shall be of the tests conducted within last five (5) years. In case the test reports are older than five (5) years, the Contractor shall repeat these tests at no extra cost to the purchaser. In the event of any discrepancy in the test reports or any type tests not carried out, same shall be carried out by Contractor without any additional cost implication to the Employer. Type Tests shall be certified or performed by reputed laboratories using material and equipment data sheets and test procedures that have been approved by the Employer.

Equipments to be delivered shall be tested at factory before despatch as per approved procedure. Factory Acceptance Test shall demonstrate the technical characteristics of the equipment in relation to this specification and approved drawings and documents. The Contractor shall provide procedures for installation and site acceptance test. The site acceptance testing will comprise of end- to-end testing between the terminal stations and RLDC/SLDC and RTAMC/other CC end. The detailed requirements for Type Test, Factory Acceptance Test and Site Acceptance Test are attached at Annexure – I

5.1 TRAINING

The Contractor will provide a training of suitable duration on supplied SDH equipment for Employer's personnel to provide working knowledge of the equipment, operation and diagnostic tools, supervision and monitoring using local craft terminal. The training may be provided by the Contractor or its sub-vendor at the site itself, preferably during installation, and will include training materials and presentation equipment. No separate charges for training shall be payable to the Contractor.

6.1 SUPPORT SERVICES

Throughout design, implementation, factory testing, and field installation and testing, the Contractor shall supply consulting assistance, as required by the Employer for site preparation, field installation, and other areas where technical support may be required.

The Contractor shall be responsible for minor facility renovation, and maintenance of the supplied system up to and including successful completion of the Site Acceptance Test.

After final acceptance of the communications equipment, the Contractor shall offer continuing technical support and spare parts for the designed life of the equipment or 7 years after the declaration of withdrawal of equipment from production whichever is earlier. However the termination of production shall not occur prior to Operational Acceptance of the system by the Employer. Some locations have existing SDH & MUX equipment. The traffic may be switched over to new fibre optic communication equipment in phase manner. The Contractor shall review the Employer existing equipment make, integration & switch over recommendation and prepare a detailed field implementation plan.

6.1.1 Technical Support

Consultation with Contractor's technical support personnel and trained field service personnel shall be readily available on a short-term/long-term basis to assist the

Employer personnel in maintaining, expanding, and enhancing the telecommunication network upon expiration of the warranty period.

6.1.2 Contractor’s Future Hardware/Software Changes

The Employer shall be informed of all alterations or improvements to the hardware supplied under this Specification. The Employer shall be placed on the Contractor's mailing list to receive announcements of the discovery, documentation, and solution of hardware/software problems as well as other improvements that could be made on supplied equipment. The service shall begin at the time of contract award, and shall continue for the designed life of the equipment. The Contractor shall also include a subscription to the hardware subcontractors' change notification service from the time of contract award through the warranty period, with a Employer renewable option for extended periods.

6.1.3 Mandatory Spare Parts

The Contractor shall be required to supply minimum spares for each subsystem as per BPS. The subsystem set of spare parts is defined to include all equipment modules, subunits and parts required to effect replacement, repair and restoration to full operational status of a defined unit of a subsystem (i.e. SDH equipment.).

6.1.4 Warranty Period

The one year period commencing immediately after the operational acceptance is called the Warranty Period/Defect liability Period. In addition to the responsibilities covered under Vol-I Condition of Contracts during Defect Liability Period, the Contractor shall also be responsible for maintenance of the Fibre Optic Transmission System etc. supplied under this Package.

6.1.5 Miscellaneous Supplies

The Contractor shall provide all required consumable and non-consumable supplies necessary to support all installation and test activities through final operational acceptance. However, if there are any problems in the SAT and additional consumables are required, the same shall also be supplied by the Contractor at no additional cost.

7.1 Documentation

The Contractor shall submit following documents during detailed engineering:

(a) Data Requirement sheets
(b) Link Budget calculations
(c) MQP, FQP

(d) Bill of Quantity including mandatory spares
(e) Previous Type test reports
(f) Factory Test report
(g) Manuals for each equipment
(h) Schematic drawing
(i) Numbering, Marking, labelling document
(j) Synchronization plan
(k) Test schedule
(l) Training manual
(m) Configuration diagram
(n) Transportation & handling Procedure
(o) Installation Manuals
(p) Maintenance Manuals

Annexure - I

Testing Requirement of Communication Equipment

1.1 List of type test to be conducted on Telecom equipment

The type tests for Telecom Equipment with all types of cards are described below:

1.1.1 Temperature and Humidity Tests

The tests listed below are defined in IEC Publication 60068.

(a) Low Temperature Test: Operation to Specifications

Low temperature tests shall be conducted as defined in IEC Publication 60068-2-1, test method Ad, with the following specifications:

(1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for sixteen (16) hours. Its performance is checked during the test.

(2) Degree of Severity: Test shall be done at 0°C

(3) Acceptance Criteria: No degradation of performance during and after the test.

(b) Low Temperature Test : Operation without Damage

Low temperature tests shall be conducted as defined in IEC Publication 60068-2-1, test method Ad, with the following specifications:

(1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 72 hours. Its performance is checked during the test and after the test as soon as the thermal equilibrium is reached at the room temperature (*Post-test*).

(2) Degree of Severity: Test shall be done at -10° C

(3) Acceptance Criteria: Degradation of performance is allowable during the test, however there shall be no degradation of performance in the *post-test*.

(c) Dry Heat Test: Operation to Specifications

Dry heat test shall be done as defined in IEC Publication 60068-2-2, test method Bd, with the following specifications:

(1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 96 hours. Its performance is checked during the test.

(2) Degree of Severity: operation to specification range.

(3) Acceptance Criteria: No degradation of performance during and after the test.

(d) Dry Heat Test: Operation without Damage

Dry heat tests shall be done as defined in IEC Publication 60068-2-2, test method Bd, with the following specifications:

(1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 96 hours. Its performance is checked during the test and after the test as soon as the thermal equilibrium is reached at the room temperature (*Post-test*).

(2) Degree of Severity: Test shall be done at 55ºC.

(3) Acceptance Criteria: Degradation of performance is allowable during the test, however there shall be no degradation of performance in the *post-test*.

(e) Damp Heat Test

Damp heat testing reveals aging with respect to the humidity level and applies basically to electronic equipment. This test shall be done as defined in IEC Publication 60068-2-3 with the following specifications:

(1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 10 days. Its performance is checked during the test.

(2) Degree of Severity: Test shall be done at (40 ± 2) °C & (93 ± 3) % RH

(3) Acceptance Criteria: The equipment shall meet the specified requirement and there shall not be any degradation in BER.

(f) Temperature Variation Test

Temperature variation testing shall be as per IEC Publication 60068-2-14 (Gradual Variations, Method Nb). The equipment shall be powered on and various parameters shall be monitored continuously during the test period.

(1) Number of cycles required is five (5)

(2) The degree of severity: temperature TL:0°C, TH: (Operation to specification range)

(3) Cycle duration for each temperature is three (3) hours.

(4) Ramp : 1 ^{o}C/minute.

(5) Acceptance Criteria: The equipment shall meet the specified requirement and there shall not be any degradation in BER.

1.1.2 Power Supply and EMI/EMC tests

The test procedure and acceptance criteria shall be as defined in IEC 60870-2-1.

(a) Immunity Tests

The list of Immunity tests are specified below in Table 4-4:

Table 4: Recommended Immunity Tests

S. No.	Immunity Test	AC Power Supply	DC Power Supply	Control & Signal	Telecom Line	Para-metres
1	Voltage Fluctuations	Yes	Yes	N/A	N/A	Table 11 of IEC 60870-2-1: 1995 - **Level : 1**
2	Voltage dips and Interruptions	Yes	Yes	N/A	N/A	
3	1.2/50 - 8/20 µs surges	Yes	Yes	Yes	N/A	Table 12 of IEC 60870-2-1: 1995 - **Level : 4**
4	Fast transient bursts	Yes	Yes	Yes	Yes	
5	Damped oscillatory waves	Yes	Yes	Yes	Yes	
6	10/700 µs surges	N/A	N/A	N/A	Yes	
7	Electrostatic discharge	Yes				Table 13 of IEC 60870-2-1: 1995 - **Level : 4**
8	Power frequency magnetic field	Yes				Table 14 of IEC 60870-2-1: 1995 - **Level : 4**
9	Damped oscillatory magnetic field	Yes				
10	Radiated electromagnetic field	Yes				Table 15 of IEC 60870-2-1: 1995 - **Level : 4**
11		N/A	N/A	Yes	Yes	

Table 4: Recommended Immunity Tests

S. No.	Immunity Test	AC Power Supply	DC Power Supply	Control & Signal	Telecom Line	Para-metres
	Power Frequency voltage on control and signal lines					IEC 61000-4-16 : 2002-07 **Level : 4**
12	DC voltage on control and signal lines	N/A	N/A	Yes	N/A	IEC 61000-4-16 : 2002-07 **Level : 4**

(b) Emission Tests

The list of Emission tests are specified below in Table 5.

Table 5: Recommended Emission Tests

S. NO.	Emission test	AC Power Supply	DC Power Supply	Control & Signal	Telecom Line	Para-metres
1	LF disturbance voltages CCITT recommendation P.53	N/A	Yes	N/A	N/A	Table 17 of IEC 60870-2-1: 1995 - Class **: B**
2	RF disturbance voltages CISPR 22	Yes	Yes	N/A	N/A	
3	RF disturbance currents CISPR 22	N/A	N/A	N/A	Yes	
4	RF radiated fields CISPR 22	Yes				

(c) Insulation Withstand Voltages

As per section 6 of IEC 870-2-1. Recommended class: VW1 of Table 18.

1.1.3 Mechanical Tests

(a) Mechanical Vibration Test

The procedure for this test is described in IEC Publication 60068-2-6. The testing procedure shall be carried out in the sequence 8.1 + 8.2.1 + 8.1 as described in document 60068-2-6. For the vibration response investigation (clause 8.1 of 60068-2-6), the test shall be carried out over a sweep cycle under the same conditions as for the endurance test (described later), but the vibration amplitude and the sweep rate may be decreased below these conditions so that the determination of the response characteristics can be obtained.

The endurance tests conditions are selected according to the vibration withstand requirements. Transportation tests shall be performed with the equipment packed according to the Contractor's specifications.

(b) Shock Test

The procedure of this test is defined in IEC Publication 60068-2-27 (each test) with a semi-sinusoidal shape (clause 3.1.1.2).

The recommended severity shall be A = 294 m/s^2, D = 18 ms. Three shocks per axis per direction shall be applied to the equipment packed according to the Contractor's specifications.

Or Free Fall Test

This test could be performed as an alternative to the shock or Bump test. The procedure is defined in IEC publication 60068-2-32. The equipment shall be packed according to the Contractor's specifications. The drop height shall be defined in accordance with IEC 68-2-32. The surface of the packing case which comes into contact with the ground is the surface on which the packing case normally rests; if the packing does not have any features (inscription, special shape, etc.) identifying this surface, the test is carried out successively on all the surfaces of the packing.

Or Bump Test

This test could be performed as an alternative to Shock test or Free Fall test. The procedure is defined in
IEC 60068-2-29.

1.2 Type tests for Optical Fibres

The type tests listed below in Table 3 shall be conducted on DWSM fibres to be supplied as part of
Approach cable. The tests specific to the cable type are listed in subsequent sections.

Table 3:Type Tests For Optical Fibres

S. No.	**Test Name**	**Acceptance Criteria**	**Test procedure**
1	Attenuation	As per Standard	IEC 60793-1-40 Or EIA/TIA 455-78A
2	Attenuation Variation with Wavelength	As per Standard	IEC 60793-1-40 Or EIA/TIA 455-78A
3	Attenuation at Water Peak	As per Standard	IEC 60793-1-40 Or EIA/TIA 455-78A
4	Temp. Cycling (Temp dependence of Attenuation)		IEC 60793-1-52 Or EIA/TIA 455-3A, 2 cycles
5	Attenuation With Bending (Bend Performance)		IEC 60793-1-47 Or EIA/TIA 455-62A
6	Mode Field dia.		IEC 60793-1-45 Or EIA/TIA 455-164A/167A/174
7	Chromatic Dispersion		IEC 60793-1-42 Or EIA/TIA 455-168A/169A/175A

Table 3: Type Tests For Optical Fibres

S. No.	Test Name	Acceptance Criteria	Test procedure
8	Cladding Diameter		IEC 60793-1-20 Or EIA/TIA 455-176
9	Point Discontinuities of attenuation		IEC 60793-1-40 Or EIA/TIA 455-59
10	Core -Clad concentricity error		IEC 60793-1-20 Or EIA/TIA 455-176
11	Fibre Tensile Proof Testing		IEC 60793-1-30 Or EIA/TIA 455-31B
-End Of table-			

1.3 Type tests for Fibre Optic Approach Cable

The type tests to be conducted on the Fibre Optic Approach cable are listed in Table 4: Type Tests for Fibre Optic Approach Cable. Unless specified otherwise in the technical specifications or the referenced standards, the optical attenuation of the specimen, measured during or after the test as applicable, shall not increase by more than 0.05 dB/Km.

Table 4: Type Tests Fibre Optic Approach Cable

S.NO.	Test Name	Test Procedure
1	Water Ingress Test	(IEC 60794-1-F5 / EIA 455-82B) Test duration : 24 hours
2	Seepage of filling compound	(EIA 455-81A) Preconditioning: 72 hours, Test duration: 24 hours.
3	Crush Test	(IEC 60794-1-E3/ EIA 455-41)
4	Impact Test	(IEC-60794-1-E4/ EIA 455-25A)
5	Stress strain Test	(EIA 455-33A)
6	Cable Cut-off wavelength Test	(EIA 455-170)
7	Temperature Cycling Test	(IEC60794-1-F1/EIA-455-3A) – 2 cycles
	-End Of Table-	

1.4 Factory Acceptance Test Requirement

Table 5: Factory Acceptance Testing for Fibre Optic Transmission System

Item:	Description
1.	Physical inspection for conformance to DRS, BOQ, drawings and appearance of equipment
2.	Optical output power
3.	Transmitter lightwave spectral analysis
4.	Low receive level threshold
5.	Generation of bit error rate curve
6.	Measurement of analog and digital service channel parameters as well as service channel functionality
7.	Performance of supervision, alarm, Craftsperson interface, diagnostics, loop backs etc.

8.	Electrical interface tests which include: output and input jitter, bit error rate, pulse shape, cable compensation, and line rate tolerance for
9.	At a minimum tests on Ethernet interface shall include demonstration of ping test,
11.	Simulation of failure conditions and failover of each redundant unit.
12.	VLAN (Layer-2 switching) feature testing configuration.
13.	Protection scheme for Ethernet Traffic (ERPS)
14.	Test of spare card slots
15.	Checks of power supply/converter voltage margins
16.	Random inspections to verify the accuracy of documentation
17.	Test of spare parts/modules/cards as per applicable tests

Table 6: FAT on NMS (Craft Terminal)	
1	Physical inspection of NMS hardware (Craft Terminal) for conformance to approved BoQ, DRS & drawing
2	Testing of NMS to demonstrate proper operation of all functions: Configuration

Table 7: Factory Acceptance Tests On Approach Cable
Factory Acceptance Test
Attenuation Co-efficient at 1310 nm and 1550 nm
Point discontinuities of attenuation
Visual Material verification and dimensional checks as per approved DRS/Drawings

Table 8: FAT on Craft Terminal	
1	Physical inspection of Craft Terminal hardware for conformance to approved BoQ, DRS & drawing
2	Testing of Craft Terminal to demonstrate proper operation of all functions

1.5 Site Acceptance Tests

All equipment shall be tested on site under the conditions in which it will normally operate.

The tests shall be exhaustive and shall demonstrate that the overall performance of the contract works satisfies every requirement specified. At a minimum Site Acceptance Testing requirement for Telecom equipment, NMS etc. is outlined in following section. This testing shall be supplemented by the Contractor's standard installation testing program, which shall be in accordance with his quality plan(s) for Telecom equipment installation.

During the course of installation, the Employer shall have full access for inspection and verification of the progress of the work and for checking workmanship and accuracy, as may be required. On completion of the work prior to commissioning, all equipment shall be tested to the satisfaction of the Employer to demonstrate that it is entirely suitable for commercial operation.

1.5.1 Phases for Site Acceptance Testing

The SAT shall be completed in following phases:

1.5.1.1 Installation Testing

The field installation test shall be performed for all equipment at each location. If any equipment has been damaged or for any reason does not comply with this Specification, the Contractor shall provide and install replacement parts at its own cost and expense.

In the installation test report, the Contractor shall include a list of all hardware or components replaced or changed between the completion of factory tests and the start of field tests and show that documentation and spare parts have been updated. The minimal installation testing requirements for fiber optic transmission subsystem are provided in the table below:

Table 9

Fibre Optic Transmission system Installation Testing

Item:	Description:
1.	Physical Inspection for conformance to drawings, rack elevations and appearance of equipment and cabling
2.	Equipment power supply (DC-DC converter) output voltage measurements
3.	Terminal transceiver performance testing (Tx power, Tx spectrum, receive signal strength, connector losses etc.)
4.	Service channel performance
5.	Craftsperson interface, alarm and control functional performance

6.	Rack and local alarms: No alarms shall be present and all alarms shall be demonstrated to be functional
7.	Network management interface and supervision performance
8.	Correct configuration, level setting & adjustments and termination of Input/ output interfaces
9.	Proper establishment of Safety and signalling earthing system and resistance to ground to be checked.
10.	Simulation of failure conditions and failover of protected components.

1.5.1.2 Link Commissioning Tests

The commissioning tests shall verify that communication can be performed over the fiber optic link under test. Delay measurement, Bit Error measurements & service channel performance monitoring shall be made on the fibre optic links to verify compliance with designed link performance.

For Ethernet interface: At a minimum the following test requirements shall be demonstrated as per RFC 2544:

a) Ping test
b) Throughput test
c) Latency test
d) Packet Loss

The links shall be tested for 12 Hour. In case any link does not meet the performance requirements during 12 hour, then the cause of failure shall be investigated and the test shall be repeated after rectifying the defects.

This phase of testing shall be conducted by the Contractor and witnessed by the Employer. Field adjustments shall be made to meet established standard, however if the field adjustments fail to correct the defects the equipments may be returned to the Contractor for replacement at his own expense. In case any adjustments are required to be made during the interval of the test then the test shall be repeated.

1.5.1.3 Integrated Testing

Prior to commencement of integrated testing the overall system shall be configured as required to provide all the data and voice channel required to interconnect to control centres and other nodes in existing system. The integrated testing shall include end-to-end testing of communication.. The intent of integrated testing is to demonstrate that the equipment is operational end to end under actual conditions, that all variances identified during factory and field installation and communications testing have been corrected, and that the communication equipment is compatible with other equipment. The Integrated System Test shall include all fibre optic transmission equipment, the network management subsystem (Craft Terminal) and other components.

At a minimum the following tests shall be included in the integrated testing:

(1) Equipment configuration shall be checked to establish that it supports the channel routing.

(2) End to end testing of all individual voice circuits (VOIP) and to demonstrate proper operation of channels over wideband systems. Operation shall be checked in terms of quality of voice, call initiation and call termination processes.

(3) End-to-end testing of all individual Data Circuits (Ethernet) and E1 channel routing. Individual port of each tributary card to be checked. Operation shall be checked in terms of monitoring of BER/packet loss.

(5) Testing of NMS (Craft Terminal) to demonstrate proper operation of all functions. All the standard features of the NMS (Craft Terminal) shall be demonstrated for proper functioning.

(6) Demonstration of Protection switching and synchronization of equipment.

Section 2: Phasor Measurement Unit (PMU) Requirements

1.0 General requirements

The offered PMUs shall be complete in all respect including GPS receiver. The PMU shall be integrated with Phasor Data Concentrators (PDCs) installed at Control centers of LDC/RLDC as per IEEE C37.118.1-2011, IEEE C37.118.2-2011 & C37.118.1a-2014 standard. The scope of Integration shall be upto the supplied PMUs and associated substation switches only.

The supplied PMUs shall be mounted in the C&R/SAS panels being supplied by the Contractor for respective substation package and interface cabling requirements shall be as applicable for relay.

1.1 PMU Requirements

1.1.1 PMU Functional Requirements

The supplied PMUs shall be compliant to M class requirements of IEEE C37.118 Standards (latest version released in 2014).

The PMUs shall communicate with PDC at Control center over the communication link provided by the Employer. For this, PMU shall be provided with One Ethernet port of 10/100 Base Tx and one optical fiber port of 100 Mbps for streaming the data in UDP/IP multicast in IEEE C37.118 format. The supplied PMUs shall be suitable to operate on unearthed 220 V DC or 110V DC or 48V DC (+10%, -15%) power supply as available in the substation.

The PMU shall support data 'Reporting Rates' of 25, and 50 frames per seconds for 50 Hz System. The actual rate to be used shall be user selectable. All the PMU hardware and software shall be sized considering 50 frames per second. The typical network architecture of PMUs at substation is given at Fig 1.1 & Fig 1.2 below. The Data Requirement Sheets (DRS) of PMUs and associated items are mentioned at Annexure-I.

Sub Station Control Room

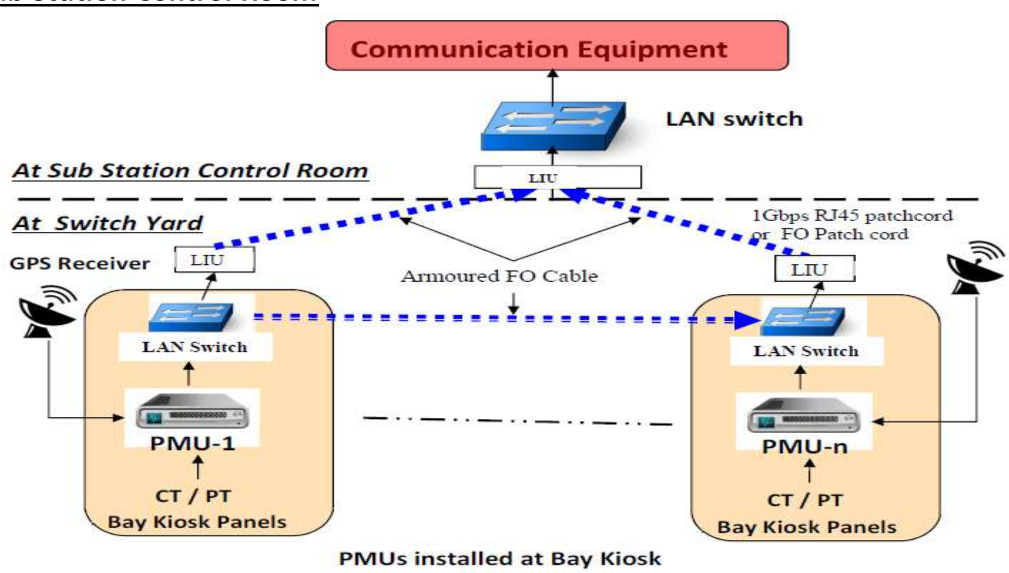


Fig 1.1: Typical Network Architecture at Sub Station Control Room

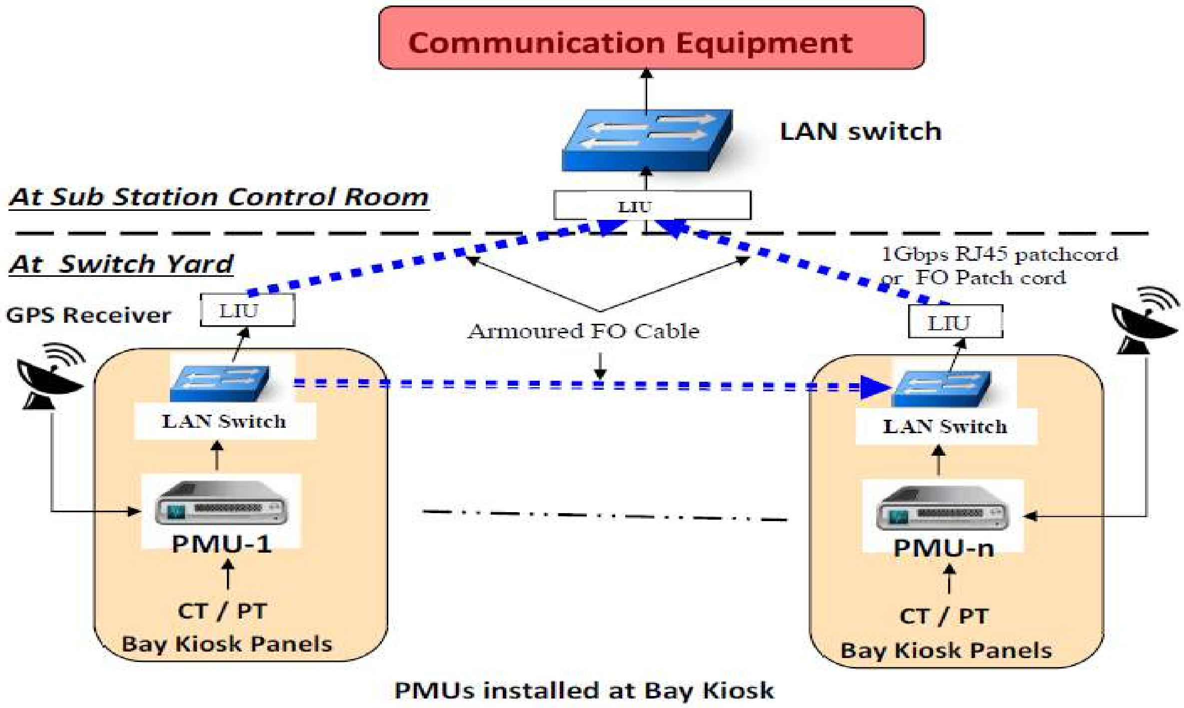


Fig 1.2: Typical Network Architecture at Sub Stations having Bay Kiosks at Switch Yard.

PMUs shall be provided to measure Voltage and Current Phasors of feeders and transformers/reactors. PMU shall also measure status of master protection and circuit breakers for units, feeders and transformers as per SLD. The PMUs shall be able to measure/calculate following:

- 3-phase voltage Phasors,
- 3-phase current Phasors,
- positive sequence voltage,
- positive sequence current,
- Breaker Status
- Main Protection Status
- Frequency,
- Rate of Change of Frequency (ROCOF) -df/dt,

Provision shall be made for user selection of measured value.

A time synchronization system (GPS receiver) shall be provided with PMU. The PMU shall have internal clock, which shall be synchronized with GPS clock. Upon loss of signal from the GPS source, the PMU shall detect a loss-of-signal and generate an alarm which will be transferred to PDC. Upon loss of signal, the PMU time facility shall revert to an internal time base. The internal clock shall have minimum stability of 1 ppm.

There shall be provision for HMI (Human Machine Interface) in PMU for configuration. The HMI shall also display the real time measured values. Alternatively Portable configuration device for PMUs can be provided for configuring the PMUs. Testing & configuration accessories such as test switch, connector, software, hardware etc., which are required for testing and configuration changes locally, shall be supplied.

The PMUs shall have continuous self-monitoring ,diagnostic feature and capable to identify & communicate problems and shall generate alarm in case of any abnormality which shall be displayed locally as well as shall be transferred to the PDC.
The Data Requirement Sheets (DRS) of PMU are mentioned at Annexure-I.

1.2 GPS based Time Facility

The PMU requires time reference to UTC. A GPS based time facility to synchronize PMU clock with Coordinated Universal Time (UTC), shall be provided except in case of in-built GPS in each PMU. The GPS receivers to be offered shall meet the supplied PMUs interface and accuracy requirements.

The time receiver shall include propagation delay compensation and shall also include an offset to permit correction to local time to achieve time accuracy of at least ± 0.2 microseconds (µs). Within one minutes of reacquisition of signal, the time shall return to within 0.2 micro-second of UTC. Proper correction of leap second shall be provided. The signal sent to PMU from the GPS receiver shall be UTC or provide information to the PMU to correct the time to UTC by using the IRIG-B time profile as per IEEE Standard C37.118. The supplied GPS shall be IEEE1588v2.0 (PTP) compliant.

The supplied GPS shall have "one IRIG-port plus 1 PPS port" and one Ethernet port as minimum.
In some of the locations, GPS shall be installed in switchyard along with PMU. GPS must be suitable to work in such Electrical environment.

1.3 Industrial Grade Layer-3 LAN Switch

The PMUs at Substations/Power Plants shall be connected to the communication equipment through an industrial grade Layer-3 LAN switch. The industrial grade LAN switch shall interface PMUs on one side and communication equipment on the other side. The LAN switch shall operate on 220V DC or 110 V DC or 48V (+10%, -15%) DC supply voltage of station.

1.4 Armoured Fibre Optic cables

Fibre optic cables within the control room shall be of armoured type for protection against rodents and physical stresses. Fibre optic cables, required to be laid in the switchyard shall also be of armored type. The characteristics of the fibre optic shall be as per the IEC 60870-5-103 standard. The fibre optic cables shall be run in GI conduit pipes while passing through cable trenches / cable racks outside the control room building. The fibre optic cables inside the panel shall be neatly laid and tied. Data Requirement Sheets (DRS) of armoured FO cables are given in Annexure-I.

1.5 Cabling & Interconnections

All cabling between component units of the PMU, PMU to GPS along with antenna and to the Employer control and relay panels (located in the substation control room) shall be supplied and installed by the Contractor and shall be shown on Contractor supplied drawings. Plug-type connectors with captive fasteners or compression type connectors shall be used for all internal interconnections. The connectors shall be polarized to prevent improper assembly. Each end of interconnection cables shall be identified by a marker which includes the cable number and the identifying number and location of each of the cable's terminations. This information shall match with the Contractor's drawings.

Adequate space and hardware shall be provided for routing of the field wiring within the enclosures. Contractor wiring within enclosures shall be neatly arranged and shall not be directly fastened to the enclosure frame. All internal interconnection wiring and cables shall be routed separately from field wiring to the PMU terminals & power wiring. All wiring shall use copper conductors and have flame retardant insulation. Conductors in multi-conductor cables shall be individually colour coded.

The use of non-flammable, self-extinguishing, plastic wire troughs is permissible. Metal clamps must have insulating inserts between the clamps and the wiring. Wiring between stationary and movable components, such as wiring across door hinges or to components mounted on extension slides, shall allow for full movement of the component without binding or chafing of the wiring.

The bidder shall be responsible for laying and termination of all cables required under the project which includes interconnections among bidder supplied equipment and their interconnection with employer's panels. Testing and commissioning of these interconnections shall also be done by the bidder.

1.6 Wiring/Cabling requirements

Shielded (screened) cables shall be used for external Cabling from the PMU/SIC panels. These external cables (except communication cables) shall have the following characteristics:

a) All cables shall have stranded copper conductor.
b) b) Minimum core cross-section of 2.5 sq.mm for PT cables, 4 sq.mm for CT cables and 2.5 sq.mm for Power & Control outputs and 1.5 sq.mm for Digital Status inputs, transducer mA current output
c) Rated voltage Uo/U of 0.6/1.1KV
d) External sheathing of cable shall have oxygen index not less than 29 & temperature index not less than 250. Cable sheath shall meet fire resistance test as per IS 1554 Part- I.
e) Shielding, longitudinally laid with overlap.
f) Dielectric withstand 2.5 kV at 50 Hz for 5 minutes
g) External marking with manufacture's name, type, core quantity, cross-section, and year of manufacture.

The Communication cable shall be of shielded, twisted pairs and of minimum 0.22sq mm size Copper cable or Fibre optic cable.

1.7 PMU TESTING

(a) <u>TypeTesting</u>

The list of Type tests applicable on the PMU is mentioned in Table-1 & type test requirements are mentioned in Table-2. The contractor may optionally submit type test reports for all the tests conducted at accredited laboratory for review & approval by Employer. However, in the event, the type test reports are not meeting the specification requirement, Employer may ask for the type testing above tests (EMI/EMC, Environmental & Functional tests) as required at no additional cost.

(b) <u>RoutineTesting</u>

Each complete unit shall undergo routine testing. The list of Routine tests to be performed in the factory is mentioned in Table-1.

(c) <u>FieldTests</u>

The Contractor shall carry out the field-testing of PMUs after installation and integration with C&R panels. The list of field tests is mentioned in Table-1.

<u>Table-1:List of Tests on PMU:</u>

Test Nos.	DESCRIPTION OF THE TEST	Type test	Routine test	Field test
	FUNCTIONAL TESTS FOR PMU			
1	Check for BOQ, Technical details, Construction & Wiring as per PMU drawings		√	√
2	Check for PMU database & configuration settings		√	√
3	Check the operation of all Analog inputs, Digital and Status input points of PMU		√	√
4	Check operation of all communication ports of PMU	√	√	√
5	Check for communication between PMU and PDC	√		√
6	Test for PMU time synchronization from GPS	√		√

Test Nos.	DESCRIPTION OF THE TEST	Type test	Routine test	Field test
7	Test Power Supply Voltage Margin, Ripple Levels and Short Circuit Protection	√		
8	Test for PMU operation with DC power supply voltage variation	√		
9	Check for auto restoration of PMU on DC power recovery after its failure	√	√	√
10	Test for PMU diagnostic feature	√		
11	Accuracy tests as per IEEE C37.118.1-2011, IEEE C37.118.2-2011 & C37.118.1a-2014 standard	√		
12	Test for PMU internal Clock stability	√		
13	End to end test (between PMU&PDC) for all I/O points			√
14	Testing and Configuration of PMU from HMI or Portable Configuration tool	√	√	√
	EMI/EMC IMMUNITY TESTS FOR PMU			
15	Surge Immunity Test as per IEC 61000-4-5& IEC 60255-22-5	√		
16	Electrical Fast Transient Burst Test as per IEC 61000-4-4 & IEC 60255-22-4	√		
17	Damped Oscillatory Wave Test as per IEC 61000-4-18 & IEC 60255-22-1			
18	Electrostatic Discharge test as per IEC 61000-4-2 & IEC 60255-22-2	√		
19	Radiated Electromagnetic Field Test as per IEC 61000-4-3 & IEC 60255-22-3	√		

Test Nos.	DESCRIPTION OF THE TEST	Type test	Routine test	Field test
20	Damped Oscillatory magnetic Field Test as per IEC 61000-4-10			
21	Power Frequency magnetic Field Test as per IEC 61000-4-8	√		
	INSULATION TEST FOR PMU			
22	Power frequency voltage withstand Test as per IEC 60255-22-5	√		
23	1.2/50 µs Impulse voltage withstand Test as per IEC 60255-22-5	√		
24	Insulation resistance test	√		
	ENVIRONMENTAL TEST FOR PMU			
25	Dry heat test as per IEC60068-2-2 / 2-3	√		
26	Damp heat test as per IEC60068-2-78	√		
27	Cold Test as per IEC60068-2-1	√		

Note: Test levels for above type tests are elaborated in Table 2

Table-2: PMU Type Test Requirements

Test Nos	Test Name	EUT Status	Test Level	Power Supply Points		I/O Points	Passing Criteria
				CM	DM	CM	
1	Surge Immunity Test	ON	Level 3	2 kV	1 kV	2 kV	A
2	Electrical Fast Transient Burst Test	ON	Level 3	2 KV	-	1 kV	A
3	Damped Oscillatory Wave Test	ON	Level 3	2.5 kV	1 kV	2.5 kV	A

4	Electrostatic Discharge Test	ON	Level 3	+/- 6 kV in Contact discharge mode or +/- 8 kV in Air discharge mode	A
5	Radiated Electromagnetic Field Test	ON	Level 3	10 V/m electric field strength	A
6	Damped Oscillatory Magnetic Field Test	ON	Level 3	10 A/m at 1MHz of magnetic field strength	A
7	Power frequency magnetic field	ON	Level 3	30 A/m of magnetic field strength (Continuous duration sine wave)	A
8	Power frequency voltage withstand	OFF	-	1 kV rms for 1 minute	No break down or flashover shall occur
9	1.2/50µs impulse voltage withstand	OFF	-	2 kVp	No break down or flashover shall occur
10	DC Voltage Dips & Interruptions / Variation as per IEC 61000-4-29	ON	-	-	-
11	Insulation Resistance Test	OFF	-	Measure Insulation resistance using 500 VDC Megger before & after Power Freq& Impulse voltage withstand tests	As per manufacturer standard
12	Dry heat test	ON	-	Continuous operation at 55^{0} C for 16 hrs	0
13	Damp heat test	ON	-	at 95% RH and 40^{0} C for 16 hrs	0
14	Cold test	ON	-	Continuous operation at 0^{0} C for 96 hrs	0

Note:-

1. EUT - Equipment Under Test
2. CM - Common Mode; DM - Differential mode
3. I/O points do not include Communication ports
4. Passing Criteria
   0 - no failure: normal performance within the specified limits
   A: minor failure: temporary degradation or loss of function or performance which is self- recoverable
5. Functional test as per the sl. nos. 1-14 of Table-1 shall also be done during type testing.

Annexure-I: BOQ for PMUs and associated items

BOQ for PMUs and associated Substation items			
S. No	**Name of the item**	**Unit**	**No of 400kV transmission lines – "x"**
	Hardware		
1	PMU	No.	X
2	Time System (GPS Receiver)	Nos.	X
3	Substation Grade Layer-3 LAN Switches with minimum 4 x 10/100 Mbps Ethernet ports and 2 x 1 Gbps Ethernet ports	Nos.	X+1
4	Armoured Fibre Optic Cable and associated termination	Lot	1
	Services		
5	Integration - PMU with PDC at RLDC and LDC	Lot	X

Note: 'X' is the no. of 400kV and above transmission lines of substations under the respective package.

In case of substations with conventional Control & relay panels.

- The no of PMUs shall be decided as per no of 400kV transmission line feeders under the scope of respective package.
- One GPS receiver shall be supplied for every 4 PMUs.
- No of LAN switches (no of ports in the LAN switch) shall be decided based on no of PMUs in a given Substation with C&R panels.

CHAPTER 20: DIESEL GENERATOR SET

1.1. SCOPE OF SUPPLY

1.1.1. The scope covers supply of. Diesel Generator set of stationary type having a net electrical output of 250kVA capacity at specified site conditions of 50^{o} C ambient temperature and 100% relative humidity on FOR site basis. DG set shall be equipped with:

(i) Diesel engine complete with all accessories.
(ii) An alternator directly coupled to the engine through coupling, complete with all accessories.
(iii) Automatic voltage regulator.
(iv) Complete starting arrangement, including two nos. batteries & chargers.
(v) Base frame, foundation bolts etc.
(vi) Day tank of 990 Litre capacity.
(vii) Engine Cooling and lubrication system.
(viii) Engine air filtering system.
(ix) Exhaust silencer package.
(x) Set of GI pipes, valves, strainers, unloading hose pipes as required for fuel transfer system from storage area to fuel tank including electrically driven fuel pump.
(xi) All lubricants, consumable, touch up paints etc. for first filing, testing & commissioning at site. The fuel oil for first commissioning will also be provided by the contractor.
(xii) AMF panel for control, metering and alarm.
(xiii) Enclosure for silent type D.G. Set

1.2. SCOPE OF SERVICE

1.2.1. The Contractor shall provide following services:

a) Design, manufacture, shop testing including assembly test.
b) Despatch, transportation to site.
c) Erection, testing & commissioning with all equipments/materials required for the purpose.
d) Drawings, data, design calculations and printed erection, operation & maintenance manual.
e) Certification and compliance for meeting noise level & emission parameters and other requirements in accordance with latest Notification of MOEF.

1.3. TECHNICAL REQUIREMENTS

1.3.1. The rating of DG sets are as follows :

DG set net out put after considering deration for engine and alternator separately due to temperature rise in side the enclosure and on account of power reduction due to auxiliaries shall be 250kVA, 1500RPM, 0.8Pf, 400V, 3 phase, 50Hz. The above ratings are the minimum requirements.

1.3.1.1. DG sets shall also be rated for 110% of full load for 1 hour in every twelve hrs of continuous running.

1.3.2. The output voltage, frequency and limits of variation from open circuit to full load shall be as follows :

a) Voltage variation — ±10% of the set value provision shall exist to adjust the set value between 90% to 110% of nominal Generator voltage of 400V.

b) Frequency — 50Hz ±2.5%

1.3.3. The Diesel Generator and other auxiliary motor shall be of H class with temperature rise limited to Class-F for temperature rise consideration.

1.3.4. NOISE LEVEL & EMISSION PARAMETERS : These shall be as per latest Notification of MOEF

1.4. PLANT DESIGN

1.4.1. DIESEL ENGINE

1.4.1.1. The engine shall comply with the BS 5514/ISO 3046; latest edition

1.4.1.2. Diesel engine shall be turbo charged multicylinder V-type in line type with mechanical fuel injection system.

1.4.1.3. The engine with all accessories shall be enclosed in a enclosure to make it work Silently (within permissible noise level) without any degradation in its performance.

1.4.1.4. The Diesel Engines shall be directly water cooled. Cooling of water through radiator and fan as envisaged.

1.4.1.5. The fuel used shall be High Speed Diesel oil (HSD) or Light Diesel Oil (LDO).

1.4.2. AIR SUCTION & FILTRATION

1.4.2.1. Suction of air shall be from indoor for ventilation and exhaust flue gasses will be let out to outside atmosphere, Condensate traps shall be provided on the exhaust pipe.

1.4.2.2. Filter shall be dry type air filter with replaceable elements.

1.4.3. FUEL AND LUBRICATING OIL SYSTEM

1.4.3.1. The engine shall have closed loop lubricating system. No moving parts shall require lubrication by hand prior to the start of engine or while it is in operation.

1.4.4. ENGINE STARTING SYSTEM

1.4.4.1. Automatic electric starting by DC starter motor shall be provided.

1.4.5. **FUEL INJECTION AND REGULATOR**

1.4.5.1. The engine shall be fitted with electronic governor.

1.4.5.2. The engine shall be fitted with a heavy, dynamically balanced fly wheel suitable for constant speed governor duty.

1.4.6. **ALTERNATOR**

1.4.6.1. The alternator shall comply with IEC 60034; latest edition.

1.4.6.2. The alternator shall be of continuously rated duty, suitable for 400 V, 3 phase, 50 Hz. Power development having brush-less, synchronous, self-excited, self-regulating system.

1.4.6.3. The alternator shall be drip-proof, screen protected as per IP-23 degree of Protection.

1.4.6.4. The rotor shall be dynamically balanced to minimize vibration.

1.4.6.5. The alternator shall be fitted with shaft mounted centrifugal fan.

1.4.6.6. It shall have the winding of class H but limited to Class-F for temperature rise consideration.

1.4.6.7. The Alternator regulator shall be directly coupled to the engine and shall be complete with the excitation system, automatic voltage regulation of +/- 1%, voltage adjusting potentiometer and under/over speed protection.

1.4.6.8. **TERMINAL BOX**

1.4.6.8.1. Six (6) output terminals shall be provided in alternator terminal box. Terminals shall be Suitable for 1 No. of single core, 630 mm^2 XLPE cables per phase for 250kVA DG set and 3½Core 300 mm^2 XLPE cable for 100kVA DG set. The neutral shall be formed in AMF panel. The generator terminal box shall be suitable to house necessary cables and should be made of non-magnetic material.

1.4.6.9. The alternator with all accessories shall be enclosed in a enclosure to make it work Silently (within permissible noise level)

1.4.7. **COUPLING**

1.4.7.1. The engine and alternator shall be directly coupled by means of self-aligning flexible flange coupling to avoid misalignment.

1.4.7.2. The coupling shall be provided with a protecting guard to avoid accidental contract.

1.4.8. MOUNTING ARRANGEMENT

1.4.8.1. The engine and alternator shall be mounted on a common heavy duty, rigid fabricated steel base frame constructed from ISMC of suitable sections.

1.4.8.2. Adequate number of anti-vibration mounting pads shall be fixed on the common base frame on which the engine and the alternator shall be mounted to isolate the vibration from passing on to the common base frame or the foundation of the D.G. Set.

1.4.9. PERIPHERALS

1.4.9.1. FUEL TANK

1.4.9.1.1. The Fuel tank of 990 Litre capacity shall be provided on a suitably fabricated steel platform. The tank shall be complete with level indicator marked in litres, filling inlet with removable screen, an outlet, a drain plug, an air vent, an air breather and necessary piping. The tank shall be painted with oil resistant paint and shall be erected in accordance with **Nepal Explosive Act.** Fuel tank shall be kept outside of enclosure. The fuel piping shall be carried out to connect the D.G set kept inside.

1.4.9.1.2. For transferring fuel to Fuel tank transfer pump is envisaged. The capacity of transfer pump shall be adequate to fill the day tank in about 30 minutes. Fuel pump shall be electrically driven.

1.4.9.2. BATTERY and BATTERY CHARGER

1.4.9.2.1. Two nos. 24V batteries complete with all leads, terminals and stand shall be provided. Each battery shall have sufficient capacity to give 10 nos. successive starting impulse to the diesel engine.

1.4.9.2.2. The battery charger shall be complete with transformer, suitable rating (400 V, 3 Ph., 50 Hz./230V, 1Ph., 50 Hz) rectifier circuit, charge rate selector switch for "trickle"/'boost' charge, D.C. ammeter & voltmeter, annunciation panel for battery charge indication / loading / failures.

1.4.9.2.3. The charger shall float and Boost Charge the battery as per recommendation of manufacturer of battery. The charger shall be able to charge a fully discharged battery to a state of full charge in 8 Hrs. with 25% spare capacity.

1.4.9.2.4. Manual control for coarse and fine voltage variation shall be provided. Float charger shall have built-in load limiting features.

1.4.9.2.5. Ripple shall not be more than 1%(r.m.s) to get smooth DC voltage shall be provided.

1.4.9.2.6. Charger shall be provided with Out-put Voltmeter & Ammeter.

1.4.9.2.7. Changeover scheme for selecting battery and battery charger by changeover switch should be provided.

1.5. CONTROL AND INSTRUMENTATION

1.5.1. Each D.G. Set shall be provided with suitable instruments, interlock and protection arrangement, suitable annunciation and indications etc. for proper start up, control, monitoring and safe operation of the unit. One local AMF control panel alongwith each D.G. set shall be provided by the Supplier to accommodate these instruments, protective relays, indication lamps etc. The AMF Panel shall have IP-52 degree of Protection as per IEC: 60529.

1.5.2. The D.G. sets shall be provided with automatic start facility to make it possible to take full load within 30 seconds of Power Supply failure.

1.5.3. Testing facility for automatic operation of D.G. Set shall be provided in AMF panel.

1.5.4. A three attempt starting facility using two impulse timers and summation timer for engine shall be proved and if the voltage fails to develop within 40 sec. from receiving the first impulse, the set shall block and alarm to this effect shall be provided in the AMF panel.

1.5.5. Following instruments shall be provided with Diesel Engine

a) Lub oil pressure gauge
b) Water temperature thermometers
c) Engine tachometer/HR
d) Any other instruments necessary for DG Set operation shall be provided.

1.5.6. DG set shall be capable of being started/ stopped manually from remote as well as local. (Remote START/STOP push button shall be provided in 400V ACDB). However, interlock shall be provided to prevent shutting down operation as long as D.G. Circuit breaker is closed.

1.5.7. The diesel generator shall commence a shutdown sequence whenever any of the following conditions appear in the system :

a) Overspeed
b) Overload
c) High temperature of engine and cooling water.
d) High temperature inside enclosure
e) Low lube oil pressure
f) Generator differential protection
g) Short circuit protection
h) Under voltage
i) Over voltage
j) Further interlocking of breaker shall be provided to prevent parallel operation of DG set with normal station supply.

1.5.8. Following indication lamps for purposes mentioned as under shall be provided in AMF panel :

1.5.8.1. Pilot indicating lamp for the following :

a) Mains ON
b) Alternator ON
c) Charger ON/OFF
d) Breaker ON/OFF
e) Main LT Supply ON/OFF

1.5.8.2. Visual annunciation shall be provided for set shut down due to :

a) engine overheating
b) low oil pressure
c) lack of fuel
d) Set failed to start in 30 secs after receiving the first start impulse
e) high cooling water temperature
f) Low level in daily service fuel tank
g) Overspeed trip
h) Audio & visual Annunciation for alternator fault.

1.5.9. Thermostatically controlled space heaters and cubicle illumination operated by Door Switch shall be provided in AMF panel. Necessary isolating switches and fuses shall also be provided.

1.5.10. AMF panel shall have facility for adjustment of speed and voltage including fine adjustments in remote as well as in local mode.

Following shall also be provided in AMF panel:

a) Frequency meter

b) 3 Nos. single phase CT's for metering

c) 3 Nos. (Provided by LT swgr manufacturer) single phase CT's with KPV 300V & RCT 0.25 ohm for differential protection of DG Set on neutral side only for 250kVA.

d) .One (1) DC Ammeter (0-40A)

e) One (1) DC Voltmeter (0-30V)

f) One (1) Voltmeter Selector switch

g) One (1) AC Ammeter

h) One (1) AC Voltmeter

i) Three (3) Timers (24V DC)

j) Two (2) Auto/Manual Selector Switch

k) Two (2) Auto/test/Manual Selector Switch

l) Eleven (11) Aux. Contactors suitable for 24V DC

m) One (1) Motorised potentiometer for voltage adjustment

n) Two (2) Set Battery charger as specified in Technical Specification

o) One (1) Set Phase & Neutral busbars.

p) Any other item required for completion of Control scheme shall be deemed to be included.

1.6. D.G. SET ENCLOSURE

1.6.1. General requirements

1.6.1.1. Diesel engine, alternator, AMF panel, Batteries and Chargers shall be installed outdoor in a suitable weather-proof enclosure which shall be provided for protection from rain, sun, dust etc. Further, in addition to the weather proofing, acoustic enclosures shall also be provided such that the noise level of acoustic enclosure DG set shall meet the requirement of MOEF The diesel generator sets should also conform to Nepal Environment (Protection) Rules. An exhaust fan with louvers shall be installed in the enclosure for temperature control inside the enclosure. The enclosure shall allow sufficient ventilation to the enclosed D.G. Set so that the body temperature is limit to 50°C. The air flow of the exhaust fan shall be from inside to the outside the shelter. The exhaust fan shall be powered from the DG set supply output so that it starts with the starting of the DG set and stops with the stopping of the DG set. The enclosure shall have suitable viewing glass to view the local parameters on the engine.

1.6.1.2. Fresh air intake for the Engine shall be available abundantly; without making the Engine to gasp for air intake. A chicken mess shall be provided for air inlet at suitable location in enclosure which shall be finalised during detailed engineering.

1.6.1.3. The Enclosure shall be designed and the layout of the equipment inside it shall be such that there is easy access to all the serviceable parts.

1.6.1.4. Engine and Alternator used inside the Enclosure shall carry their manufacturer's Warranty for their respective Models and this shall not degrade their performance.

1.6.1.5. Exhaust from the Engine shall be let off through Silencer arrangement to keep the noise level within desired limits. Interconnection between silencer and engine should be through stainless steel flexible hose/ pipe.

1.6.2. All the Controls for Operation of the D.G. Set shall be easily assessable. There should be provision for emergency shut down from outside the enclosure.

1.6.3. Arrangement shall be made for housing the Battery set in a tray inside the Enclosure.

1.6.4. CONSTRUCTION FEATURES:

1.6.4.1. The enclosure shall be fabricated from at least 14 Gauge CRCA sheet steel and of Modular construction for easy assembling and dismantling. The sheet metal components shall be pre-treated by Seven Tank Process and Powder coated (PURO Polyester based) both-in side and out side – for long life. The hard-ware and accessories shall be high tensile grade. Enclosure shall be given a lasting anti-rust treatment and finished with pleasant environment friendly paint. All the hardware and fixtures shall be rust proof and able to withstand the weather conditions.

1.6.4.2. Doors shall be large sized for easy access and provided with long lasting gasket to make the enclosure sound proof. All the door handles shall be lockable type.

1.6.4.3. The Enclosure shall be provided with anti-vibration pads (suitable for the loads and vibration they are required to carry) with minimum vibration transmitted to the surface the set is resting on.

1.6.4.4. High quality rock wool of required density and thickness shall be used with fire retardant thermo – setting resin to make the Enclosure sound proof.

1.6.5. Provision for Neutral/Body Earthing

1.6.5.1. Points shall be available at two side of the enclosure with the help of flexible copper wires from alternator neutral, and electrical panel body respectively. The earthing point shall be isolated through insulator mounted on enclosure.

1.7. INSTALLATION ARRANGEMENT

1.7.1. DG set enclosed in enclosure shall be installed on Concrete Pedestal 300mm above FGL.

1.8. DOCUMENTS

1.8.1. Following drawings and data sheet shall be submitted for approval:

(i) Data sheet for Engine, Alternator, Battery, AMF panel and Enclosure
(ii) GA drawing of DG set
(iii) Layout of DG set in the enclosure along with sections
(iv) GA and schematic of AMF panel
(v) Arrangement of inclined roof and pedestal.

1.8.2. The D G Set shall be supplied with

(i) D G Set test certificate
(ii) Engine Operation & maintenance Manual.
(iii) Engine Parts Catalogue.
(iv) Alternator Operation, maintenance & Spare parts Manual.
(v) Alternator test certificate.

1.9. TESTS

a) The Diesel generator sets shall be tested for routine and acceptance tests as per the relevant IEC standards.

1.10. COMMISSIONING CHECKS

In addition to the checks and test recommended by the manufacturer, the Contractor shall carryout the following commissioning tests to be carried out at site.

1. Load Test

The engine shall be given test run for a period of atleast 6 hours. The set shall be subjected to the maximum achievable load as decided by Purchaser without exceeding the specified DG Set rating:

During the load test, half hourly records of the following shall be taken:

a) Ambient temperature.
b) Exhaust temperature if exhaust thermometer is fitted.
c) Cooling water temperature at a convenient point adjacent to the water output from the engine jacket.
d) Lubricating oil temperature where oil cooler fitted.
e) Lubricating oil pressure.
f) Colour of exhaust gas
g) Speed
h) Voltage, wattage and current output.
i) Oil tank level

The necessary load to carryout the test shall be provided by the purchaser.

2. Insulation Resistance Test for Alternator

   Insulation resistance in mega-ohms between the coils and the frame of the alternator when tested with a 500V megger shall not be less than IR=2x(rated voltage in KV)+1

3. Check of Fuel Consumption

   A check of the fuel consumption shall be made during the load run test. This test shall be conducted for the purpose of proper tuning of the engine.

4. Insulation Resistance of Wiring

   Insulation resistance of control panel wiring shall be checked by 500V Megger. The IR shall not be less than one mega ohm.

5. Functional Tests

   a) Functional tests on control panel.
   b) Functional test on starting provision on the engine.
   c) Functional tests on all Field devices.
   d) Functional tests on AVR and speed governor.

6. Measurement of Vibration

   The vibration shall be measured at load as close to maximum achievable load and shall not exceed 250microns.

7. Noise Level shall be less than 75dBA at a distance of one meter.

8. The tests shall be carried out with the DG set operating at rated speed and at maximum achievable load. Necessary correction for Test environment condition & background noise will be applied as per applicable IEC/International Standards.

CHAPTER 21: HV & EHV XLPE POWER CABLE

1 CABLE CONSTRUCTION DETAILS

1.1 The XLPE insulated EHV cable shall conform to the requirements of IEC 60502-2 (applicable clauses only) for construction and IEC 60840/IEC 62067 (as applicable) for testing. The terminating accessories shall conform to IEC 60840/ IEC 62067 (as applicable). The offered cables and its terminating accessories shall be compatible with each other.

1.2 The EHV grade cable shall be single core, unarmoured, stranded, compacted **Copper** conductor, core screening by a layer of semiconducting tape followed by a layer of semiconducting compound, cross linked polyethylene (XLPE) dry cured insulation, insulation screening with semiconducting compound extruded directly over the insulation, longitudinal sealing by a layer of non-woven tape with water swellable absorbent over insulation screen, followed by radial sealing (Metal sheath of Lead alloy 'E'), metallic screening by concentric layer of plain copper wire (if required) to meet short time current requirement, followed by an open helix of copper & overall HDPE sheathed & graphite coated and conforming to the technical particulars of specification. Bidder may offer necessary layers such as separation tape, binder tapes etc additionally as per their manufacturing practices for meeting required performance of the offered cable.

1.3 The cable shall be suitable for lying under the climate conditions (as specified in Section-Project) and underground buried installation with uncontrolled back fill and chances of flooding by water.

1.4 Cable shall be designed to withstand all mechanical, electrical and thermal stresses under steady state and transient operating conditions.

1.5 Progressive sequential marking of the cable length (in metres), at every one metre, shall be provided on the outer sheath of the cable.

1.6 Repaired cables shall not be accepted.

1.7 Allowable tolerance on the overall diameter of the cables shall be $\pm$ 2 mm.

1.8 CONDUCTOR

The conductor shall be of **Copper/Aluminium** wires as specified in the Bid Price Schedule **(BPS)**. The shape of conductor shall be compacted segmental having high compactness and smooth surface finish.

1.9 CONDUCTOR SCREEN

The conductor screen shall consist of extruded semi-conducting XLPE. Semi-conducting separator tapes may be applied between conductor and the extruded semi-conductor XLPE. The conductors screen (non-metallic semi-conductive) shall be extruded in a single one-time process to ensure homogeneity and absence of voids.

1.10 INSULATION

The extruded XLPE insulation shall be applied over the conductor screen to the desired thickness in a void free manner.

1.11 INSULATION SCREEN

The insulation screen shall consist of extruded semi-conducting XLPE. Suitable bedding tapes shall be applied over the extruded semi-conducting XLPE.

1.12 MOISTURE BARRIER

Longitudinal water barrier:
The longitudinal water barrier shall be applied over insulation screen by a layer of Non woven synthetic tape with suitable water swellable absorbent.

Radial Moisture Barrier:
This shall be of extruded Lead alloy “E” sheath.

1.13 METALLIC SCREEN:

The metallic screen shall be of plain copper wires, helically applied over the radial moisture barrier. A binder tape of annealed plain copper shall be applied in the form of an open helix over the copper wire screen. The combination of the metallic sheath (lead sheath) in combination with wire screen shall be designed to meet the requirement of the system short circuit rating as specified in **the bidding documents**.

1.14 OUTER SHEATH

The outer sheath shall consist of extruded black coloured HDPE with graphite coating. The outer sheath shall be suitably designed by the addition of chemicals in the outer sheath for protection against termite and rodent attack and shall be coated with graphite.

1.15 RATING

The contractor/ manufacturer shall declare current rating of cable for maximum conductor temperature of 90 degree C under continuous operation and 250 degree C during short-circuit condition. The contractor/ manufacturer shall also declare over load curve with duration for conductor temperature of 105 Deg C. A complete set of calculation made in arriving at the current rating shall be furnished, for laying condition envisaged under the project, during detailed engineering for Employer/Owner’s reference.

1.16 CABLE JOINTING ACCESSORIES

1.16.1 The cable jointing accessories shall include all the straight through joints, Cross bonding, earth continuity cables, Link boxes, Sheath Voltage Limiters (SVLs) etc as required for entire cable route. Bidder shall arrange all special tools and tackles required for making these joints at his own cost. **Unless specified separately** in BPS, **cable end terminating kits** shall be deemed included as part of cable jointing accessories.

1.16.2 The straight through joint shall preferably be built up from the same material as the main cable and shall have electrical and mechanical withstand capabilities same as or better than the main cable. The joints shall be suitable for tropical conditions as specified in **Chapter 1-Project Specific Requirement**.

1.16.3 The straight through joints and cable end terminations shall be of proven design and should have been type tested as per relevant IEC. A list of supply of cable jointing accessories which are in successful operation in projects, shall be furnished.

1.16.4 The detailed description on jointing procedure shall be furnished during detailed engineering.

1.16.5 The cable end terminations shall be of anti-fog type and shall be of Polymer type/Porcelain type suitable for withstanding the climatic conditions with required Creepage distance as specified in **bidding documents**. The cable end terminals for terminating the cables shall be complete with accessories & fully compatible with the cables to be supplied. The terminations shall also be capable to withstand mechanical forces during normal and short circuit operations.

1.16.6 The cable end terminations envisaged for **GIS interface,** shall comply to IEC 60840. It will be the responsibility of the contractor to ensure smooth interface with GIS equipment.

2 CABLE DRUMS

2.1 Cables shall be supplied in returnable steel drums of heavy construction of suitable size and packed conforming to applicable standards.

2.2 Standard drum lengths for manufacturing shall be finalized during detailed engineering. Each drum shall carry the manufacturer's name, the purchaser's name, address and contract number and type, size and length of the cable, net and gross weight stencilled on both sides of drum. A tag containing the 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.

2.3 Packing shall be sturdy and adequate to protect the cables from any injury due to mishandling or other conditions encountered during transportation, handling and storage. Both cable ends shall be sealed with PE/Rubber caps so as to eliminate ingress of water during transportation and erection.

3 TESTS ON CABLES

All XLPE insulated EHV cables shall conform to all Type, Routine and Acceptance tests listed in the relevant IEC & shall submit the type test reports for Employer's approval. If specified in Section-Project, Type tests shall be carried out on the EHV cable as per relevant standard.

4 TESTS ON ACCESSORIES

Contractor shall submit type test reports for accessories, as per IEC 60840:1999/ IEC 62067 for Employer's acceptance. Contractor shall submit type test reports as per clause no. 9.2 of Technical Specification, Chapter 2: GTR for Employer's acceptance.

5 TESTS AFTER INSTALLATION

All tests on cable system as prescribed in IEC 60840:1999/IEC 62067 (as applicable) shall be performed after installation.

6 CABLE HANDLING

The inspection of cable on receipt, handling of cables, paying out, flaking, cushioning with sand or sieved compacted soil, back-filling, reinstatement of road surfaces, providing and fixing joint markers, route indicators, precautions of joint holes, sump holes and all necessary precautions that are required shall be carefully planned and in accordance with acceptable standard practices/statutory requirements.

7 BENDING RADIUS

The minimum bending radius of XLPE insulated cables shall be 20XD where "D" means the Outer diameter of the cable.

8 CABLE LAYING & TERMINATIONS

The preparation of the cable end for installing the terminations and the precautions to be taken before fixing the terminations shall be followed as in the case of the cable jointing procedures. The instructions furnished by the termination manufacturer shall be strictly followed.

At cable terminating end, the following provisions for supply and erections are to be included:

(i) A sufficient length of spare cable shall be left in the ground, for future needs.

(ii) The rise of the cable immediately from the ground shall be enclosed in

PVC/PE pipe of suitable diameter to protect against direct exposure to the sun.

(iii) The cable shall be properly fastened using non-metallic clamps.

(iv) Appropriate labels shall be fixed identifying the phase circuit, voltage and date of commissioning etc., on the cable supporting structure.

(v) The sealing end shall be mounted on pedestal insulators to isolate them from their supporting steel work.

(vi) Protection from contact with the exposed metal work at the termination shall be provided by resin bonded glass fibre shroud.

(vii) Providing earth stations with all required materials, like leads, connectors etc. Earth pits shall conform to IS–3043:1987 (Code of practice for earthing)/ or equivalent International standards.

9 BONDING OF SCREEN/ SHEATH

The screens/sheath shall be cross-bonded under each segment of specified route in accordance with IS-3043 (Code of practice for earthing) or applicable International codes & practices. The bidder shall offer complete cable system in order to limit maximum sheath voltage in accordance with relevant standards and furnish complete set of calculations in support of the same. The screen/sheath shall be connected to the earth stations/ earth pits through disconnecting type link boxes & through Sheath Voltage Limiter (SVL) as required.

All required materials used in the Cross bonding, termination of earth continuity cable, Link box, SVL etc to comply with specification/statutory requirements shall be in the scope of bidder and should be of good quality and compatible with the cable.

10 CONNECTION OF RADIAL WATER BARRIER AND CABLE SCREEN

If the metallic radial water barrier is insulated from the metallic wire screen, a connection suitable to carry the currents occurring during operation must be installed between metallic radial water barrier of the cable and metallic wire screen in joints and sealing ends.

11 CABLE TERMINATING STRUCTURES

11.1 The terminating structure being supplied, should be designed as per the project requirement for the cable end terminations i.e. for Standalone Outdoor AIS terminations, GIS end terminations and Transmission line Tower end terminations as per requirement specified in BPS.

11.2 The mounting structure shall be fixed on the reinforced cement concrete foundation, the design & drawings of which shall be submitted to Employer for review & acceptance during detailed engineering.

11.3 The mounting structure includes the supports for cable end boxes, link boxes and any other item required for the intent of the contract. All steel sections used shall be free from all imperfections, mill scales, slag intrusions, laminations, fillings, rust etc. that may impair their strength, durability and appearance. All materials shall be of tested quality only unless otherwise permitted by the Employer. The steel for mounting structure shall confirm to IS-2062 (latest).

11.4 In case of cable terminations on transmission line towers, the cable termination kit, LA, Link Box, SVL etc shall be fixed suitably on the tower for which necessary interface details shall be coordinated for Tower design during detailed engineering. After fixing the end terminations, the cable shall be suitably fixed to the tower members, with non-magnetic material clamps to the required height securely. The cable in air shall be suitably protected using HDPE pipes up to certain height.

11.5 In case of GIS end terminations, the structure & foundations shall be suitably designed in coordination with GIS terminations during detailed engineering.

12 CABLE ROUTE MARKERS/CABLE JOINT MARKERS

Permanent means of indicating the position of joints and cable route shall be fabricated supplied and erected as per approved drawings.

Markers provided shall be as per the field requirement, if the route passes through open fields, markers should be conspicuously visible and above ground surface.

The marker should incorporate the relevant information such that the name of the
Owner, voltage, circuit and distance of cable from the marker.

13 JOINTING AND TERMINATION OF CABLES

The cable jointing personnel and his crew shall have good experience in the type of joints and terminations that are used. The jointing work shall commence as soon as two or three lengths of cables have been laid. All care should be taken to protect the factory-plumbed caps/ seals on the cable ends, and the cable end shall be sealed whenever the end is exposed for tests.

Jointing of cables in carriage ways, drive ways under costly pavings, under concrete or asphalt surfaces and in proximity to telephone cables and water mains should be avoided whenever possible.

Sufficient over lap of cables shall be allowed for making the joints.

The joint bay should be of sufficient dimensions to allow the jointers to work with as much freedom of movement and comfort as possible. Sufficient space should be kept below the cable to be jointed.

The joints of different phases shall be staggered in the jointing bay.

13.1 SUMPHOLES

When jointing cables in water logged ground or under unforeseen rainy conditions, a sumphole should be made at one end of the joint bay, in such a position so that the accumulated water can be pumped or baled out by buckets, without causing interference to the jointing operation.

13.2 TENTS/COVERS

An enclosure or suitable protection cover shall be used in all circumstances wherever jointing work is carried out in the open, irrespective of the weather conditions. The joint shall be made in dust free, moisture free and clean atmosphere.

13.3 PRECAUTIONS BEFORE MAKING A JOINT

The cable end seals should not be opened until all necessary precautions have been taken to prevent circumstances arising out of rainy/ inclement weather conditions, which might become uncontrollable.

If the cable end seals or cable ends are found to have suffered damage the cables should not be jointed, without tests and rectification.

13.4 MEASUREMENT OF INSULATION RESISTANCE

Before jointing, the insulation resistance of both sections of cables shall be checked.

13.5 IDENTIFICATION

The identification of each phase, shall be clearly and properly noted. The cables shall be jointed as per the approved design. Each cable shall have identification for phase at joint bays.

13.6 MAKING A JOINT

Comprehensive jointing instructions should be obtained from the manufacture of jointing kits and meticulously followed.

The materials used in the joints like ferrules, screen/sheath continuity bonds, lugs etc., shall be of good quality and conform to standards.

The jointing tools shall be appropriate and as per the requirement of jointing EHV XLPE cables.

Chapter 22: Technical Data Sheets

1.0	**AIR CONDITIONING**	
Sl.No	**Description**	**Offered Data**
1	Manufacturer's Name & Model	
2	Star Rating	
3	Compressor Cooling capacity	
4	Rated current -cooling	
5	Rated Power input- cooling	
6	Rated EER	
7	Power Supply	
8	Air Flow Volume- Indoor	
9	Noise level - Indoor	
10	Operation	
11	Compressor type a)Compressor make b)Compressor sealed	
12	Refrigerant	
13	Indoor unit Dimension (WxHxD)	
14	Indoor unit Net/Gross weight	
15	Outdoor unit Dimension (WxHxD)	
16	Outdoor unit Net/Gross weight	
17	Connecting Pipe with Cable	
18	Length	
19	Connecting Box Dimension (WxHxD)	
20	No of Boxes	
	a)ODU	
	b)Connecting pipe	
	c)IDU	
21	Features	
	a)Filters	
	b)Coil	
	c)Copper tubes	
	d)IDU	
	e)Remote	

Signed ____________________
As representative for _________________________
Address _______________________________________
Date______________________________________

2.0 BATTERIES & BATTERY CHARGERS

Sl.No	Description	Offered Data	
		220V	48V
A.	**BATTERIES**		
1.0	Manufacturer's Name & address		
2.0	Confirm whether Manufactures have Manufactured, tested, supplied, installed and commissioned batteries of 220V, 600AH, capacity similar to the offered batteries and are in operation for at least 2(Two) years		
3.0	Type of battery		
4.0	Capacity of battery at 27°C		
5.0	Whether batteries are type tested as per IEC		
6.0	Recommended value of float charging voltage		
B.	**BATTERY CHARGERS**		
1.0	Manufacturer's Name & address		
2.0	Confirm whether Manufactures have Manufactured, tested, supplied, installed and commissioned battery chargers of 10 KW capacity similar to the offered battery charger		
3.0	Capacity of battery charger (AH)		
4.0	Charger rate/output current		
5.0	Float charging mode (A)		
6.0	Boost charging mode (A)		
7.0	Ripple content in output voltage %		
8.0	Confirm whether battery chargers are type tested as per specification		

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3.0 BAY CONTROL UNIT

SN	Description	Offered Data
1.0	Name of Manufacturer	
2.0	Type of unit Mounting	
3.0	Manufacturer's type designation	
4.0	Standards Applicable	
5.0	Rated Auxiliary Voltage	
6.0	No. of analogue variable (Specify Voltage & Current Separately)	
7.0	Rated frequency (Hz)	
8.0	No. of binary inputs	
9.0	No. of output	
10.0	Language	
11.0	Type of communication protocol supported by unit	
12.0	No. & Type of communication ports	
13.0	Operating temperature range	
14.0	System response time	
14.1	Exchange of display	
14.2	Presentation of Binary Change	
14.3	Presentation of Analogue Change	
14.4	Order to process output	
14.5	Order to update display	
14.6	Report Generation	

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4.0 OUTDOOR SF6 CIRCUIT BREAKERS

SN	Description	Offered Data	
		245 KV	72.5KV
1	Name of the Manufacturer		
2	a)Type of Circuit Breaker		
	b)Type of tank (Live / Dead)		
3	Manufacturer's type designation		
4	Standards Applicable		
5	Rated Voltage (kVrms)		
6	Rated continuous current at design temperature of 50 deg.C (Amps)		
7	Rated frequency (Hz)		
8	Number of poles		
9	Whether 3 pole or single pole unit		
10	No. of breaks per pole		
11	Rated short circuit breaking current		
	i) Symmetrical component at highest system voltage (kAp)		
	ii) DC Component (%)		
	iii) Asymmetrical breaking current at highest system voltage (kA)		
12	Rated Making Capacity		
	i)at higher rated voltage (kAp)		
	ii)at lower rated voltage (kAp)		
13	i). Maximum total break time under any duty condition for any current upto rated breaking current with limiting conditions of voltage and pressure (ms)		
	ii)Rated break time as per IEC condition (ms)		
	iii)Closing time (ms)		
	iv)Maximum opening time under any condition with limiting voltage and pressures (ms)		
	v)Maximum close open time under any(ms)		
14	First pole to clear factor		
15	Short time current rating for 1 second (kA)		
16	Rated operating duty		
17	Maximum line charging breaking current with temporary over voltage upto 1.4 p.u (kA)		
18	.i) Maximum period between closing of first contact & last contact in a pole (ms)		

SN	Description	Offered Data	
		245 KV	72.5KV
	ii) Maximum pole discrepancy (ms)		
19	Pre-insertion resistor		
	i)Value/pole (Ohms)/ with tolerance (ohms)		
	ii)Minimum and maximum duration of		
20	Small fault current breaking capacity (Amps)		
21	Maximum temperature rise for main contacts over design ambient temperature of 50 C (Deg. C)		
22	Rated pressure and limits of pressure of operating Mechanism (kg/sq.cm)		
23	Rated pressure and limits of pressure of extinguishing medium (kg/sq.cm)		
24	Minimum dead time for		
	i) Three phase reclosing (ms)		
	ii) Single phase reclosing (ms)		
25	Dielectric Withstand Voltage of Complete Breaker		
	i) One minute dry & wet power frequency withstand voltage		
	a)Between live terminal and ground (kV rms)		
	b)Between terminals with breaker contacts Open (kVrms)		
	ii) 1 2/50 micro second impulse withstand test voltage.		
	a)Between live terminals and ground (kVp)		
	b) Between terminals with breaker contacts Open (kVp)		
	iii) 250/2500 micro second switching surge withstand test voltage		
	a)Between live terminals and ground (kVp)		
	b)Between terminals with breaker contacts Open (kVp)		
	iv)Corona extinction voltage `		
	v)Maximum radio interference voltage at 1.1 Ur/root 3		
	vi)Total creepage distance		
	a) To ground		
	b) Between terminals		
	Operating Mechanism		

SN	Description	Offered Data	
		245 KV	72.5KV
26	a) Type of operating mechanism for		
	i) Closing		
	ii) Opening		
27	SF6 Circuit Breakers		
	a)Quantity of SF6 per pole at rated pressure (cu.m)		
	b)Guaranteed maximum leakage rate per year (kg/sq.cm)		
	c)Rated pressure of SF6 in operating chamber (kg/sq.cm)		
	d)Limits of pressure at which breaker operates correctly (kg/sq.cm)		
	e)Minimum time interval between each Make/break operation (ms)		
28	General		
	a)Weight of complete3 phase breaker for foundation design (kg)		
	b)Impact loading Foundation design		
	c)Seismic level for which Breaker is designed (g)		
	d)Min. safety clearance from earthed objects		
	e)Noise level in Base of the breaker (dB) and upto 50m distance from base		
	Minimum clearance In air		
	i)between live parts (mm)		
	ii)live parts to earth (mm)		
	iii)live parts to ground level (mm)		
	g) Compliance to technical specification w.r.t parameters specified for		
	i)Control Cabinet		
	ii)Bushing/support Insulator		
	iii)Terminal connector.		
	iv) SF6 Gas		
	Detailed Literature		

SN	Description	Offered Data	
		245 KV	72.5KV
29	a)Whether similar equipment are type tested as per IEC and are in successful operation for at least 2 (two) years (If yes, furnish type test reports)		
	b)Furnish data on capabilities of circuit breaker in terms of time and number of operations at duties ranging from 100 % fault currents to load currents of the lowest possible value without requiring any maintenance or checks		
	c)Furnish details of effect of non simultaneity between contacts within a pole or between poles and also show how it is covered in the guaranteed rated break time.		
	d)Overall General Arrangement drawing of circuit breaker is to be enclosed.		

Signed ____________________

As representative for _________________________

Address _______________________________________

Date_______________________________________

5.0	**CONTROL AND RELAY PANELS**	
SN	**Description**	**Offered Data**
1	Name and address of Manufacturer of panels	
2	Manufacturer's type and designation	
3	Type of construction (Simplex/duplex)	
4	Thickness of sheet steel	
	(i)Front	
	(ii)Back	
	(iii)Sides	
5	Degree of protection	
6	Name of the manufacturer of relays	
7	DC voltage of the relays	
8	Make and Model of static (0.2 accuracy class type) energy meters	
9	Confirm whether offered manufacturer of C&Rpanels and protective relays have tested commissioned & they are in successful operationfor at least five years in 132 kV system	
I	**TRANSMISSION LINE PROTECTION**	
A	**Numerical Distance protection Scheme**	
1	Name and address of Manufacturer	
2	Manufacturer's type and designation	
3	Switched or Non- switched type (is it with separate measurements for single/three phase faults)	
4	Setting range of offset feature	
5	Whether the relay is having self monitoring feature	
6	Whether relay is compatible for Optical Fiber equipment and can be used for Permissive Under reach/over reach /Blocking scheme etc	
7	Suitable for single and three phase Trip?	
8	Type of shaped characteristic	
9	No of tripping contacts with making capacity of 30 amp for 0.2 seconds	
10	In case 16 contacts as per above clause are not available with the distance relay offered , type of tripping relay being	
11	Maximum operating time for at 50% of the reach setting of 2 ohms and 10/20 ohms (with CVT) including all trip relays	

SN	Description	Offered Data
	a)at SIR=4	
	b)at SIR=15, (3 phase faults)	
	c)at SIR=15 (other faults)	
12	IDMT earth fault relay Meeting Normal Inverse Characteristics as per IEC 60253 is being offered as built in	
13	If no, type of IDMT relay being offered	
14	Built in features offered with the relay (YES/NO)	
	a)Disturbance recorder	
	b)Fault locator	
	c)Over voltage (one stage only)	
	d)Auto reclose along with Dead line charging and check synchronisng	
B	**BACKUP DIRECTIONAL OVER CURRENT AND EARTH FAULT PROTECTION SCHEME**	
1	Name and address of Manufacturer	
2	Manufacturer's type and designation	
3	Three over current and one E/F elements Are whether independent or composite unit	
4	Type of relay (Elecromechanical /static/Numerical)	
5	Directional sensitivity	
6	Whether characteristic conform to IEC 255-3	
7	Over current unit setting range inverse time	
8	Earth fault unit setting range inverse time	
9	VT Fuse failure relay/ feature included for alarm	
C	**LINE OVER VOLTAGE PROTECTION RELAY**	
1	Name and address of Manufacturer	
2	Manufacturer's type and designation	
3	Type of relay (Elecromechanical /static/Numerical)	
4	Operation indicator provided?	

SN	Description	Offered Data
5	Operating time	
6	Resetting time	
7	Whether monitors all three phases?	
8	Built in feature of Main1/Main 2 distance relay is offered. If so , which stage is offered as built in	
D	**DISTANCE TO FAULT LOCATOR**	
1	Name and address of Manufacturer	
2	Manufacturer's type and designation	
3	Built in feature of Main1/Main 2 distance relay is offered	
4	Maximum registering time	
5	Whether direct display unit provided?	
6	Whether both phase to phase fault and phase to earth fault measuring units included?	
7	Whether "On-Line" type	
8	Accuracy for the typical conditions defined under technical specification	
F	**DISTURBANCE RECORDER**	
	a. Acquisition unit	
1	Name and address of Manufacturer	
2	Manufacturer's type and designation	
3	No. of analogue channels	
4	No. of digital recording channels	
7	Built in feature of Main1/Main 2 distance relay is offered	
6	Pre-fault memory (milli seconds)	
7	Post fault memory(seconds)	
8	Total storage memory in seconds	
9	Sampling frequency	
10	Resolution of event channels	
11	Time display present?	
12	Data output in comtrade is available?	
	b. Evaluation Unit	

SN	Description	Offered Data
1	Name and address of Manufacturer	
2	Manufacturer's type and designation	
3	No of acquisition unit that can be connected to One evaluation unit	
4	Technical Parameters of evaluation unit	
	A Processor and speed	
	B RAM and hard disk capacity	
	C Additional facilities	
	D Details of printer	
5	Details of power supply arrangement for Acquisition unit (including printer)	
G	**AUTO RECLOSE RELAY**	
1	Name and address of Manufacturer	
2	Manufacturer's type and designation	
3	Electromechanical /static/numerical	
4	Auto reclose relay along with Dead line charging and check synchronizing relay (For 132 KV lines) offered as a part of	
5	Suitable for single and three phase?	
6	Single phase dead time setting Range	
7	Three phase dead time setting range	
8	Reclaim time setting range	
II	**TRANSFORMER PROTECTION**	
A	**Differential relay**	
1	Name and address of Manufacturer	
2	Manufacturer's type and designation	
3	Second harmonic restraint provided	
4	Whether three instantaneous units provided	
5	Operating Current setting range	

SN	Description	Offered Data
6	Bias setting range	
7	Operating time at 5X setting current	
8	Resetting time	
9	How ratio / phase angle corrections are being done (inter posing transformer/internal feature in the relay)	
B	**Restricted Earth Fault Protection**	
1	Name and address of Manufacturer	
2	Manufacturer's type and designation	
3	Operating time at 2 X setting	
C	**Over Fluxing relays**	
1	Name and address of Manufacturer	
2	Manufacturer's type and designation	
3	Whether inverse time operating characteristics	
4	Maximum operating time	
5	Accuracy of operating time	
6	Resetting time	
D	**Directional O/C and E/F relays**	
1	Name and address of Manufacturer	
2	Manufacturer's type and designation	
3	Whether Characteristic will confirm to IEC255-3	
4	Directional sensitivity	
5	Over current unit setting range	
	a) Inverse time	
	b) High set	
6	Earth fault unit setting range	
	a) Inverse time	

SN	Description	Offered Data
	b) High set	
	GENERAL PROTECTION /MONITORING EQUIPMENT	
	Trip Circuit Supervision relay	
1	Name and address of Manufacturer	
2	Manufacturer's type and designation	
3	Whether pre-closing and post closing supervision provided?	
4	Time delay	
	High Speed Trip Relays	
1	Name and address of Manufacturer	
2	Manufacturer's type and designation	
3	Contact ratings	
	a) Make and carry continuously	
	b) Make and carry for 0.5 sec.	
	c) Break	
	i). Resistive load	
	ii) Inductive load (With L/R=40milli sec.)	
4	Operating time at rated voltage(maximum)	
5	Resetting time	
6	Whether supervisory relays included	
E	**Local breaker back-up protection**	
1	Name and address of Manufacturer	
2	Manufacturer's type and designation	
3	Operating time	
4	Resetting time	
5	Setting ranges	
	a) Current	
	b) Time	

SN	Description	Offered Data
III	**Bus bar Protection**	
1	Name and address of Manufacturer	
2	Manufacturer's type and designation	
3	Type of relay (Elecromechanical /static/Numerical)	
4	Principle of operation (Biased/High impedance)	
5	Operating time	
6	Resetting time	
7	Setting ranges	
	i)Current	
	ii)Time	
8	Whether will it cause tripping for the differential current below the load current of heavily loaded feeder (Bidder	

Note: Bidders shall provide the additional details of the offered equipments in line with Technical Specifications

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As representative for _________________________
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6.0 OUTDOOR CURRENT TRANSFORMER

S.No	Description	Offered Data	
		245KV	72.5KV
1.0	Name of Manufacturer		
2.0	Manufacturer's type designation		
3.0	Standards Applicable		
4.0	Type of CT (Live or dead Tank)		
5.0	Rated Voltage		
6.0	Rated frequency (Hz)		
7.0	Rated Current		
	a)Rated Continuous current		
	b)Rated extended primary current		
8.0	Short time thermal current withstand for 1 sec		
9.0	Dynamic current withstand		
10.0	1.2/50micro sec impulse withstand voltage		
11.0	250/2500micro sec switching surge withstand voltage		
12.0	One minute dry and wet power frequency withstand voltage		
13.0	No. of primary winding		
14.0	No. of cores per CT		
15.0	Current ratio for all cores		
16.0	Output burden for all cores		
17.0	Accuracy class for all cores		
18.0	Knee point voltage of at different taps for all cores		
19.0	Corona Extinction		
20.0	Partial discharge level		
21.0	Total weight		
22.0	Max exciting current at Knee point voltage at different ratio.		
23.0	Secondary winding resistance at all different ratio		

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As representative for ________________________
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Date_____________________________________

7.0	**OUTDOOR CAPACITOR VOLTAGE TRANSFORMERS & VOLTAGE TRANSFORMERS**		
S.N	**Description**	**Offered Data**	
		420kV CVT	**72.5 KV PT**
1.	Name and address of Manufacturer		
2.	Manufacturer's type designation		
3.	Standards applicable		
4.	Rated primary voltage Ur (kV)		
5.	Rated secondary voltages (kV)		
6.	Number of secondaries		
7.	Rated frequency (Hz)		
8.	Rated output of each secondary winding (VA)		
9.	Total simultaneous burden (VA)		
10.	Rated total thermal burden (VA)		
11.	Highest system voltage (kV)		
12.	Rated voltage factor and corresponding rated time		
13.	Accuracy class of each secondary winding		
14.	Capacitance		
	i. of high voltage capacitor (pF)		
	ii. of intermediate voltage capacitor (pF)		
15.	Carrier frequency coupling (pF)		
16.	Natural frequency of coupling (kHz)		
17.	Self tuning frequency of CVT (kHz)		
18.	Band width (kHz)		
19.	One minute power frequency test voltage of secondary winding (kV rms)		
20.	One minute power frequency test voltage of H.F. terminal (kV rms)		
21	One minute power frequency test voltage of capacitor (kV rms) (dry & wet)		
22	1.2/50 micro s impulse withstand test voltage of Capacitor (kVp)		
23	250/2500 micros switching surge withstand voltage of capacitor (dry & wet) (kVp)		

S.N	Description	Offered Data	
		420kV CVT	72.5 KV PT
24	Corona extinction voltage (kV rms)		
25	Max. Radio interference voltage at 1.1 Ur/Root 3 at 1.0 MHz (Micro volts)		
26	Total weight (kg)		
27	Quantity of oil (litres)		
28	Whether CVTs are hermetically sealed. If so. How		
29	Compliance to technical specification w.r.t		
	i) Bushing Insulator		
	ii) Control Cabinet		
	iii) Terminal Connectors		
30	Whether similar equipment is type tested as per IEC 186 and in successful operation for at least 2 (two) years		
31	Overall General Arrangement drawing of CVT is to be enclosed.		

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As representative for _________________________

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8.0 ISOLATORS / GROUNDING SWITCHES

SN	Description	Offered Data	
		245 kV	72.5 kV
1.	Name and address of the Manufacturer		
2.	Manufacturer's type designation		
3.	Standard applicable		
4.	Rated Voltage Ur		
5.	Rated Current under site conditions at 50 deg.C ambient (Amps)		
6.	Rated frequency (Hz)		
7.	Number of poles		
8.	Whether all 3 poles are ganged mechanically		
9.	Pole to pole spacing (mm)		
10.	Rated short time current of isolator and earth switch for 1(one) second and dynamic current		
11.	Opening time of isolator and earth switch		
12.	Closing time of isolator and earth switch		
13.	Rated mechanical terminal load		
14.	Dielectric withstand capacity of completely assembled isolator/ earth switch		
15.	One minute dry power frequency withstand test voltage		
	i) against ground (kVrms)		
	ii) across isolating distance (kVrms)		
16	1.2/50 micro sec impulse withstand test voltage		
	i)against ground (kVp)		
	ii)across isolating distance (kVp)		
17	250/2500 micro sec switching surge withstand test voltage (dry & wet)		

SN	Description	Offered Data	
		245 kV	72.5 kV
	i)against ground (kVp)		
	ii)across isolating distance (kVp)		
18	Corona Extinction voltage (kVrms)		
19	Radio interference level at 1.1 Ur/ root 3 (in micro volts) at 1 MHz		
20	Operating Mechanism		
	i)For main blades		
	ii)For earth switches		
21	Controls		
	i)Rated DC control voltage (V)		
	ii)Limits of voltage		
22	Constructional Features		
	i) Main Contacts		
	a)Type of contacts		
	b) Contact Area (sq.cm)		
	c)Material of contact		
	d)Contact pressure (kg/sq.cm)		
	e)Max. current density under (A/sq.cm) normal current carrying capacity		
	f)Thickness of silver plating (Microns)		
23	Compliance to Technical specification w.r.t		
	i) MOM Box		
	ii) Support insulators		
	iii) Terminal Connectors iii) YES / NO		

SN	Description	Offered Data	
		245 kV	72.5 kV
24	Whether similar equipment are type tested as per IEC and are in successful operation for at least 2 (two) years		
25	Overall General Arrangement drawing of Isolator/ Earth switch is to be enclosed.		

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9.0 LIGHTING SYSTEM

Sl. No	Description	Offered Data
A.	**LIGHTING FIXTURES & ACCESSORIES**	
1.0	Manufacturer's Name & address	
	a) Fixtures b) Accessories	
2.0	Applicable Standards for	
	a) Fixtures b) Accessories	
4.0.	Maximum permissible supply voltage variation for satisfactory operation of	
	a) Fixtures	
	b)Accessories	
B.	**CONDUIT & ACCESSORIES (FOR EACH TYPE & SIZE)**	
1.0	Manufacture's Name & address	
2.0	Manufacturer's type, designation	
3.0	Applicable standard	
C.	**JUNCTION BOXES (FOR EACH TYPE & SIZE)**	
1.0	Manufacture's Name & address	
2.0	Manufacturer's type, designation	
3.0	Type of enclosure	
D.	**LIGHTING PANELS (FOR EACH TYPE & SIZE)**	
1.0	Manufacture's Name & address	
2.0	Type	
3.0	Degree of Protection	
E	**LIGHTING TRANSFORMER**	
1.0	Manufacture's Name & address	
2.0	Type	
3.0	Rating	
4.0	Standards Applicable	
5.0	Degree of protection for Enclosure	
F	**LIGHTING POLES**	
1.0	Manufacture's Name & address	
2.0	Type	
3.0	Dimension	
G.	**LIGHTING WIRES**	
1.0	Manufacture's Name & address	
2.0	Voltage Grade	
3.0	Cross section of conductor	
4.0	Insulation Thickness	

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10.0 Auto Transformer

S.N.	Bidders/ Description	Offered Data	
		400/220//33 315 MVA, 3-Phase	167MVA, 1-phase, 400/√3/220/√3/33 KV
1	Name of manufacturer		
2	Normal full load single phase/three phase output:		
	H.V. Winding (KVA)		
	L.V. Winding (KVA)		
2.1	Temp. Rise as specified in the specification.		
3	Continuous single phase/three phase output under, Site conditions as specified in the specification		
	H.V. Winding (KVA)		
	L.V. Winding (KVA)		
4	Type of cooling and corresponding normal Full load output		
	H.V. Winding (KVA)		
	L.V. Winding (KVA)		
5	Over load capacity starting from Full load and with Temp. as specified in the Specification (KVA)		
6	Normal ratio of transformation		
7	Connection (including vector group reference & Symbol)		
	H. V. Winding		
	L.V. Winding		
8	Type of tap changer		
9	Tapping		
	a) Number		
	b) Range		
	c) Location		
10	Details of Automatic Voltage Regulator		
	(a) Make		
	(b) Model etc.		
	(c) Short description (other)		
11	Type of core construction		
12	i) Temp. rise by resistance of winding (ºC)		
	ii) Temp. rise in oil by thermometer (ºC)		
	iii) Hot spot temp. for which the transformer is designed (ºC)		
13	Limit for hot spot temp. for which the transformer is designed (ºC)		
14	Guaranteed no load loss at rated voltage & rated frequency and 75ºC average winding temperature		
15	Guaranteed load losses at rated current rated voltage, rated frequency and 75 ºC average winding temp. KW (excluding auxiliary losses)		
	for ONAN cooling		
	for ONAF cooling		
	for OFAF cooling		
16	a) Auxiliary losses at rated output – KW		
	b) Total losses at normal ratio, rated output, rated voltage, rated frequency and maximum attainable temp. at site including auxiliary losses – KW		
	(c) Stray eddy losses as % of total losses		
17	Exciting current power factor (Amp. %)		
	i) At normal voltage & frequency		
	ii) At maximum voltage and normal frequency		
18	Efficiency at 75 ºC Unity P.F.		

S.N.	Bidders/ Description	Offered Data	
		400/220//33 315 MVA, 3-Phase	167MVA, 1-phase, 400/√3/220/√3/33 KV
	i) On 100% load (%)		
	ii) On 75% load (%)		
	iii) On 50% load (%)		
	iv) On 25% load (%)		
19	Efficiency at 75 ºC 0.8 P.F. (Lag)		
	i) On 100% load (%)		
	ii) On 75% load (%)		
	iii) On 50% load (%)		
	iv) On 25% load (%)		
	v) Load at which maximum efficiency occurs (% of full load)		
20	Maximum efficiency (%)		
21	a) Percentage reactance at rated current and frequency		
	b) Percentage impedance at rated current and frequency at 75 ºC		
	i) Positive sequence		
	ii) Zero sequence		
	c) Range of variation (+,-) offered		
	d) Tolerance applicable if any		
22	Impedance voltage drop at normal ratio at 75ºC expressed as a percentage of normal voltage on full load (%)		
23	Regulation on full load at unity P.F. at 75 ºC expressed as a percentage of normal voltage (%)		
24	Regulation on full load 0.8 P.F. lagging at 75ºC expressed as a percentage in the winding		
25	Maximum current density & c/s area in the winding (Guaranteed and As per SC calculation)		
	i) H.V. (Amp./Sq. cm.)		
	ii) Cross sectional area		
	iii) L.V. (Amp/Sq. cm)		
	iv) Cross sectional area		
26	Maximum flux density in the core		
26.a	Core details		
	i) Material of core lamination		
	ii) Thickness of core plates (mm)		
	iii) Insulation of core lamination		
	iv) Insulation of core clamping plates		
	v) Press board material & thickness		
	vi) Prime quality grade		
27	Core joints (butt or inter leave)		
28	Type of winding		
	i) H.V.		
	ii) L.V.		
29	Type of radial support		
	i) High Voltage Winding		
	ii) Lower Voltage Winding		
30	Insulation of higher voltage winding		
31	Insulation of lower voltage winding		
32	Thickness of transformer tank plates		
	i) Sides (mm)		

S.N.	Bidders/ Description	Offered Data	
		400/220//33 315 MVA, 3-Phase	**167MVA, 1-phase, 400/√3/220/√3/33 KV**
	ii) Bottom (mm)		
	iii) Cover (mm)		
	iv) Radiator (mm)		
33	(A) POWER FREQUENCY WITHSTAND VOLT		
	i) Test voltage for 1 min. P.F. withstand test on live end of high voltage winding (KV rms)		
	ii) Test voltage for 1 min. P.F. withstand test on neutral end of high voltage winding (KV rms)		
	iii) Test voltage for 1 min. P.F. withstand test on live end of low voltage winding (KV rms)		
	(B) IMPULSE TEST		
	i) Test voltage for 1.2/50 micro sec. Full wave withstand test on high voltage winding (KV crest) on		
	ii) Test voltage for 1.2/50 micro sec. Full wave withstand test on low voltage winding (KV crest) on		
34	Inter-turn Insulation		
	i) Extent of end turns reinforcement		
	ii) Extent of reinforcement of turns adjustment to tap		
	iii) Test voltage for 1 min. 50 Hz. Inter-turn insulation test on (i) (KV rms)		
	iv) Test voltage for 1 min. 50 Hz. inter-turn insulation test on (ii) (KV rms)		
	v) Test voltage for 1 min. 50 Hz. inter-turn insulation test on main body of the winding (KV rms)		
35	Type of winding temperature indicator		
36	Maxi continuous ratings		
	i) At 50 C ambient air temp. at site (KVA)		
	ii) At 40 C ambient air temp. at site (KVA)		
	iii) At 30 C ambient air temp. at site (KVA)		
	iii) At 20 C ambient air temp. at site (KVA)		
37	Details of Air cell		
	Make		
	Type		
	Capacity		
	Size		
38	Width of track gauge (Meters)		
39	Bushing Particulars		
	(a) HV Bushing		
	i) Type of high voltage bushing and creepage distance in mm		
	ii) Rated current		
	iii) STC rating for 3 sec		
	iv) Weight of high voltage bushing in Kg		
	v) Quantity of oil in one high voltage bushing Insulator, in litre		
	vi) Dry 1 minute power frequency test voltage value of high voltage bushing in KV		
	vii) Wet 10 second power frequency test voltage value of high voltage bushing in KV		
	viii) Impulse withstand test voltage value with 1.2/50 microsecond full wave of high voltage bushing in KV		

S.N.	Bidders/ Description	Offered Data	
		400/220//33 315 MVA, 3-Phase	167MVA, 1-phase, 400/√3/220/√3/33 KV
	(b) LV Bushing		
	i) Type of low voltage bushing and creepage distance in mm		
	ii) Rated current		
	iii) STC rating for 3 sec		
	iv) Weight of low voltage bushing in Kg		
	v) Quantity of oil in one low voltage bushing Insulator, in litre		
	vi) Dry 1 minute power frequency test voltage value of low voltage bushing in KV		
	vii) Wet 10 second power frequency test voltage value of low voltage bushing in KV		
	viii) Impulse withstand test voltage value with 1.2/50 microsecond full wave of low voltage bushing in KV		
	(c) NEUTRAL Bushing		
	i) Type of low voltage bushing and creepage distance in mm.		
	ii) Rated current		
	iii) Weight of bushing insulator in kg		
	iv) Quantity of oil in one bushing in litres		
	v) Dry 1 minute power frequency withstand and test voltage value of bushing in KV		
	vi) Wet 10 second power frequency withstand test voltage value of bushing in KV		
	vii) Impulse withstand test voltage with 1.2/50 microsecond fall wave of bushing in KV		
40	Clearance		
	a) Minimum clearance between phase (Mtrs.)		
	i) In oil		
	ii) Out of oil		
	b) Minimum clearance of high voltage to earth in oil (Mtrs)		
	c) Minimum clearance of high voltage to tank in oil (Mtrs)		
41	Net weight of the core (Kgs.)		
42	Net weight of copper (Kgs.)		
	a) H.V. (Kgs.)		
	b) L.V. (Kgs.)		
	c) Total (Kgs.)		
43	Weight of core and windings		
44	Weight of fittings		
45	Net untanking weight(Kgs.)		
46	Weight of tank and cover (Kgs.)		
46.1	Tank dimensions		
46.2	Guarantee against leakage for 3 years		
47	Weight of oil in transformer including bushings, conservator and cooling system (Kgs.)/Quantity (Ltrs.)		
48	Weight of oil in transformer (including bushings) (Kgs)		
49	Weight of complete transformer with oil and all fittings (Kgs.)		
50	Weight of transformer with all fittings but without oil (Kgs.)		
51	Weight of the package to be transported and dimensions		
52	Dimensions of the transformers		

S.N.	Bidders/ Description	Offered Data	
		400/220//33 315 MVA, 3-Phase	167MVA, 1-phase, 400/√3/220/√3/33 KV
	i) Maximum height upto top of bushings (Mtrs.)		
	ii) Overall length (Mtrs.)		
	iii) Overall width (Mtrs.)		
53	Minimum clear height for lifting core and windings from tank in meters		
54	Details of on load tap changing gear		
	a) Make		
	b) Type		
	c) Rating		
	i) Rated Voltage		
	ii) Rated current		
	iii) Step Voltage		
	iv) STC rating		
	d) Time for complete tap change (Sec.)		
	e) Diverter selector switch transition time (Cycles)		
	f) Control		
	g) Auxiliary supply details		
	h) Voltage control		
	i) Protection devices		
	j) Value of Maxi. Short circuit current		
	k) Maxi. Impulse withstand test voltage value with 1.2/50 microsecond full wave between switch and ground		
	l) Maxi. Impulse withstand test voltage value with 1.2/50 micro sec. Full wave between the remote terminal and ground with the selector terminal at one end of the range		
	m) Maxi. Power frequency test voltage between switch assembly and range		
	n) Maxi. Impulse withstand test voltage with 1.2/50 micro sec. across the tapping range		
	o) Maxi. Temp. of the tap changer which must not be exceeded during operation :		
	p) Approximate overall weight (kg)		
	q) Approximate overall dimensions (Mtrs)		
	r) Approximate overall quantity of oil (Kgs.)		
55	No. of operations (approx.) after which the change of oil is necessary :		
56	Any other particulars which need a mention		
57	Cooling calculation shall be submitted		
58	**OIL LOAD TAPCHANGING GEAR**		
	i) Make		
	ii) Type designation		

S.N.	Bidders/ Description	Offered Data	
		400/220//33 315 MVA, 3-Phase	**167MVA, 1-phase, 400/√3/220/√3/33 KV**
	iii) Suitable for auto/manual operation (YES / NO)		
	iv) Rated voltage (KV)		
	v) Rated current (Amps)		
	vi) Step voltage (Volts)		
	vii) Number of steps		
	viii) Rated voltage of drive motor (V)		
	ix) List of routine tests to be carried out		
	x) Location of the taps with respect to the terminals of the tapped winding		
	xi) Drawing or pamphlet-number of the technical and descriptive particulars of the OLTC, enclosed with the Bid.		

Signed ____________________
As representative for _________________________
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Date______________________________________

11.0 LT Switchgear

Sl. No	Description	Offered Data
1	Manufacturer's Name	
2	Whether Manufacturer's have supplied 50 Nos draw out Air circuit breaker Panels out of which 5 Nos. are with CT and relaying scheme.	
3.	Whether Manufacturer's have supplied 50 Nos. MCC panels similar to the offered panels.	
4.	Whether 100 nos.(at least) circuit breakers of the make and type being offered are already been operating satisfactorily.	
4.	Rated short circuit current	
5.1	Symmetrical short circuit withstand current at rated voltage of switchgear cubicle	
5.2	Peak short circuit withstand current	
6.	Degree of protection	
6.1	Breaker/MCC/AC & DC	
6.2	Distribution Cubicles	
6.3	Busbar chamber	
7.	Standard height, width & depth of typical panel	
7.1	Circuit Breaker Panel	
7.2	MCC panel	
7.3	AC/DC Distribution Board	
8.	Width of cable alley	
9.	Whether equipment are type tested as per IEC	

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12 1.1 KV Power and Control Cables

SN	Description	Offered Data
1	Manufacturer's name and address	
2	Manufacturer's type & designation	
3	Applicable standards	
4	Rated Voltage (Volts)	
5	Suitable for earthed or unearthed system?	
6	Continuous current rating when laid in air in an ambient temp. of 50deg.C and for maximum conductor temp. of 70 deg.C for PVC cable	
7	**Short Circuit Capacity**	
i.	Short Circuit Current (kArms)	
ii.	Duration of short circuit. (Sec.)	
iii.	Conductor temp. allowed for the short circuit duty (Deg. C)	
iv	Formula relating short circuit current (rms) and duration (Sec.)	
8	**Conductor(Circular)**	
i.	Material (Copper or aluminium)	
ii.	Grade	
iii.	Normal cross section area (Sq.mm)	
iv	Approx.Number and diameter of wire before stranding(No./mm)	
9	**Insulation**	
i.	Composition of insulation	
ii.	Nominal thickness of insulation (mm)	
10	**Inner Sheath**	
i.	Material	
ii.	Calculated diameter over the laid up cores, (mm)	
iii.	Thickness of Sheath (minimum) mm	
11	**Armour**	
i.	Type and material of armour (wire / strip)	
ii.	Calculated diameter under armour (mm)	
iii.	Nominal diameter of round armour wire	
iv	Nominal size of strip	
v	Short circuit capacity armour alongwith formulae(kA)	
vi	Maximum D.C. resistance at 20deg.C	
12	**Outer Sheath**	
i.	Material	
ii.	Calculated diameter under sheath	

SN	Description	Offered Data
13	Safe pulling force when pulled by pulling eye on the conductor (Kg)	
14	**Test Voltage**	
i	High Voltage test voltage (kV)	
ii	Water immersion test voltage (kV)	
15	Minimum bending radius permissible	
16	Whether the cables are type tested as per IEC	

Signed ____________________

As representative for _________________________

Address _______________________________________

Date______________________________________

13	Shunt Reactor	
SN	**Description**	**Offered Data**
1	Name of manufacturer	
2	Governing Standard	
3	Type of reactor	
4	Type of cooling	
5	Connection	
6	a) Reactive power for continuous operation (MVAR)	
	I) At rated voltage	
	II) At highest voltage (i.e. 5% higher than rated) (MVAR)	
	b) Rated voltage	
	c) Temperature rise in oil above ambient temp. ºC	
	d) Temperature rise of winding by resistance above ambient temperature ºC	
	e) Rated frequency (Hz)	
7	Number of Phases	
8	Guaranteed Losses at rated voltage and frequency corrected to 75 deg. C Wdg. Temp (kW)	
a	Load losses	
b	Auxiliary losses	
c	Total losses	
9	State whether the losses are firm or Subject to tolerance. In a case it is subject to tolerance indicate the ceiling for tolerance (in percent)	
10	Impedance :	
	a) Positive sequence (Ohms)	
	b) Zero sequence (Ohms)	
11	Ratio of reactor (i.e. Q-factor)	
12	Maximum remissible duration of service at 110% of rated voltage, starting from cold without exceeding permissible temperature rise(hrs.)	
13	Noise level and reference standard (db).	
14	Test voltage (for winding)	
	a) ightning impulse (1.2/50 micro-seconds) withstand voltage (KV peak)	
	b) Power frequency withstand voltage (KV rms.)	
	c) Switching surge withstand voltage (KV peak)	
15	Clearances:	
	a) HV phase to Phase (mm)	
	b) Phase to Ground (mm)	
	c) Neutral to Ground (mm)	
16	Approximate weights (kgs.)	
	a. Core (kgs.)	
	b. Winding (kgs.)	
	c. Tank and fittings(kgs.)	

SN	Description	Offered Data
	d. Oil (kgs.)	
	e. Total weight (kgs.)	
	f. Untanking weight (kgs.) (to provide access to core and coils)	
17	Quantity of oil (including 10% extra) itars.	
18	Conservator	
	a) Total volume	
	b) Volume between highest and lowest visible oil levels.	
19	(a) Size of largest package (mm x mm x mm)	
	(b) Weight of largest package (kgs.)	
	(c) Gross weight to be handled (kgs.)	
	(d) Gross volume to be handled (M3)	
20	Bushing as per IS : 2099	
	a) Type	
	b) Maker's name and country of Manufacturer	
	c) Momentary power Frequency withstand voltage	
	d) One minute power frequency withstanding voltage	
	i) Dry (KV)	
	ii) Wet (KV)	
	e) Power Frequency puncture voltage (KV)	
	(d) Full wave impulse withstand and voltage (KV)	
	(f) Impulse puncture voltage (KV)	
	(h) Total creepage distance in air	
	(i) Weight and dimensions of assembled Bushings. (KV)	
21	Core	
	a) Type of core	
	b) Justification for type of core adopted	
	c) Technical details of the core	
	i) Material	
	ii) Thickness in mm	
	iii) Grade (Prime only)	
	iv) Insulation of core lamination	
	v) Press board material and thickness	
22	Winding details	
	a) Type of winding	
	b) Material of the winding conductor	
	c) Maximum current density for windings at rated Voltage	
	d) Whether graded or full insulation	
	e) Insulating material used for winding	
	f) Type of axial coil supports	
	g) Type of radial coil supports	
23	Stress on tank wall	
24	Zero Sequence Reactance/ positive sequence reactance i.e. XO/XI	
25	Range of voltage up to which impedance will be constant and magnetization curve up to 2.5 pu. Voltage.	
26	Vibration level	

SN	Description	Offered Data
27	Amount of unbalanced current in each phase whenconnected to symmetrical voltages.	
28	Capacitance value (Phase to Ground)	
29	Type of oil preservation system	
30	Harmonic content in Phase current	
31	Quality of oil (please enclose separate sheet for characteristics of oil)	
32	Cooling calculation shall be submitted	

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14 Substation Automation System

SN	Name of the component	Offred Data
I	**ETHERNET SWITCH**	
	Name & Address of the Manufacturer	
	Model	
	Type of switches	
	Mounting arrangement	
	Power consumtion	
	Protocol Supported	
II	**SERVER 1&2**	
	Make	
	Type/ Model	
	Construction	
	Operating system	
	Processor (Type /Make)	
	Processor speed	
	FSB	
	Chipsel	
	Memory capacity (RAM)	
	Hard disk	
	Ethernet Port	
	Power supply	
	Power consumption	
III	**STATION HMI,REDUNDANT AND STATION HMI DR,CUM ENGINEERING WORKSTATION**	
	Make	
	Type/ Model	
	Construction	
	Operating system	
	Processor (Type /Make)	
	Processor speed	
	FSB	
	Chipsel	
	Memory capacity (RAM)	
	Hard disk	
	Ethernet Port	
	Power supply	
	Power consumption	
IV	**TFT Monitor**	
	Name of the Manufaturer	
	Viewable area	
	Contrast Ratio	
	Response time	
	Optimum resolution	

SN	Name of the component	Offred Data
	Frequency	
	Digital Input	
	Operating temparature	
	Dimension (W X H X D)	
	Audio Speaker	
	Display	
V	**TIME SYNCHRONISING EQUIPMENT**	
	Name and address of the Manufaturer	
	Reference Standard	
	Name of Satelite system and type of time signal	
	Number of satelite that can be traked	
	Mounting arrangement	
	I/P and O/P ports	
	Power supply	
	Power consumption	
	Operating temparture	
	Whether able to give real time IST corresponding to(taking in to consideration all factors like voltage temparature variation & propagation / Processing delay)	
	Accuracy	
	Time display unit	
VI	**COLOUR LASER PRINTER**	
	Name and address of the Manufacturer	
	Auxilary voltage	
	Offline/Online mode selector	
	Printer encloser provided	
	Print speed	
	First page out	
	Resolution	
	Processor	
	Standard memory	
	Duty cycle	
	Operating system	
	Network Interface	
VII	**DOT MATRIX PRINTER**	
	Name and address of the Manufacturer	
	No of colums	
	Auxilary voltage	
	Noise Level	
	Interface	
	Built in testing facility	
	Offline or online mode selector	
	Printing Method	
VIII	**FIBRE OPTIC PATCH CABLE**	

SN	Name of the component	Offred Data
	Name and address of the Manufacturer	
	Wavelength	
	Unarmoured/ Armoured type	
	Type of conectors used	
	Type of cable	
	Proper identification	
	Core diameter	
	Attenuation at 850nm	
	Numerical aperture	
	No of cores per cable	
	Type of Material	
IX	**ARMOURED FIBRE OPTIC CABLE**	
	Name and Address of Manufacturer	
	Wavelength	
	Type of connectors used	
	Type of cable	
	Core diameter	
	Attenuation at 850nm	
	Numerical aperture	
	No. of cores per cable	
	No. of Spare cores	
	Type of Material	
XI	**INVERTER**	
	Name and address of the Manufacturer	
	Capacity	
XII	**Substation Automation System Software m**	
	Make	
	Type	
XIII	**Substation Automation System erection & commissioning Agency**	
	Name and Address	
	Type of future Service in Nepal	

Note: Bidders shall provide the additional details of the offered equipments in line with Technical Specifications

Signed ______________________
As representative for ___________________________
Address ____
Date____

15.0 SURGE ARRESTERS

S.No.	Description	Offred Data		
		400KV	220KV	33kV
1	Name and address of Manufacturer			
2	Manufacturer's type designation			
3	Applicable standards			
4	Arrester class and type			
5	Rated arrester voltage (kV)			
6	Rated system voltage (kV)			
8	Maximum continuous operating voltage (COV) at 50 deg.C ambient temperature (kV)			
9	Nominal discharge current(8/20 micro sec.wave) (kA)			
10	Minimum discharge capability (kJ / kV)			
11	(a)Maximum residual voltage at nominal discharge current (kVpeak)			
	b)Minimum residual voltage at nominal discharge current (kVpeak)			
	(c)Maximum residual voltage at 50 % nominal discharge current (kVpeak)			
	(dMaximum residual voltage at 200% nominal discharge current (kVpeak)			
12	Steep fronted wave residual voltage at 1 KA (kVpeak)			
13	Maximum switching surge impulse residual voltage at 1 KA (kVpeak)			
14	Long duration discharge class			
15	a)High current short duration (4/10 micro-sec wave) in kVpeak			
	b)Low current long duration (2000 microsec.)			
16	Current for pressure relief test (kA)			
17	Pressure relief class (as per IEC 99)			
18	One minute power frequency (dry) withstand voltage of arrester housing (kVrms)			
19	Lightning Impulse withstand test voltage of arrester housing with 1.2/50 microsec wave (kVp)			
20	Switching Surge Impulse withstand test voltage of arrester housing with 250/2500 microsec wave (kVp)			
21	Total creepage distance of whole arrester Housing (mm)			
22	Cantilever strength of complete arrester (N)			
23	Total height of the arrestor (mm)			
24	Total weight of the arrestor (kg)			

S.No.	Description	Offred Data		
		400KV	220KV	33kV
25	Maximum radio interference voltage at 1.1 Ur/ root 3 voltage at 1 MHz (microvolts)			
26	Partial discharge at 1.05 continuous operating voltage (pC)			
27	Minimum prospective symmetrical fault current (kArms)			
28	Compliance to technical specification w.r.t			
	i)Surge monitor			
	ii) Support Insulator			
	iii)Terminal connectors			
29	ZnO block details			
	a)Make and size of ZnO block			
	b) Whether equipment type tested with offered type of ZnO block			
30	Whether similar equipment are type tested as per IEC or equivalent standard and are in successful operation for at least two years.			
31	Overall General Arrangement drawing of Surge arrester is to enclosed.			

Signed ____________________
As representative for _________________________
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Date_______________________________________

16.0 INSULATOR , HARDWARES & ACCESSORIES

Sl.No.	Description	Offred Data			
		400kV	220kV	72.5kV	33kV
A.	**Long Rod Composite Insulators**				
1	Manufacturer's name and address				
2	Applicable Standards				
3	Shed and Housing Material				
4	Maximum shed diameter (mm)				
5	Shed spacing (mm)				
6	Housing thickness over core (mm)				
7	Core material				
8	Core Diameter (mm)				
9	End Fitting Material				
10	Grade of malleable cast iron				
11	Thickness of galvanising of metal end fittings (µm)				
12	Coupling Length (mm)				
13	Specified Mechanical Load (SML) (kN)				
14	Routine Test Load (RTL) (kN)				
15	1 minute Failing Load (kN)				
16	96 hour Withstand Load (kN)				
17	Maximum Mechanical Load (MML) (kN)				
18	Minimum Arc Distance (mm)				
19	Minimum Creepage Distance (mm)				
20	Power Frequency Wet Withstand Voltage				
	(a) Horizontal (kV rms)				
	(b) Vertical (kV rms)				
21	Power Frequency Dry Withstand Voltage (kV rms)				
22	Minimum Power Frequency Wet Flashover Voltage (kV rms)				
23	Minimum Power Frequency Dry Flashover Voltage (kV rms)				
24	Impulse Withstand Voltage (kV pk)				
25	Minimum Impulse Flashover Voltage (kV pk)				
26	RI Applied Voltage: (kV)				
27	RIV measured across 300 degree at 1 MHz (µV)				
28	Ball coupling designation to AS2947.3 (mm)				
29	Socket coupling designation to AS2947.3				
30	Socket coupling fitted with W-clip supplied with insulator				
B.	**INSULATOR STRINGS**				

Sl.No.	Description	Offred Data			
		400kV	220kV	72.5kV	33kV
1	Manufacturer's name and address				
2	Applicable Standards				
3	No. of Units per String				
4	**Weight**				
	a) Each Disc (Kg)				
	b)Complete string (hardware only) (Kg)				
5	Creepage Distance				
	a)Each Disc (mm)				
	b) Complete String (mm)				
6	Power Frequency Withstand Voltage of the complete string with corona control ring				
	i.Dry (KVrms)				
	ii.Wet (KVrms)				
7	Lightning Impulse (dry) Withstand Voltage of the Complete string for both positive and negative peaks. (kVp)				
8	Switching Surge withstand Voltage of the Complete string with corona control (Wet) (kVp)				
9	Power Frequency Puncture Withstand Voltage (Dry & Wet) of each Disc (KV rms)				
10	Electro Mechanical Strength of each Disc (Kg)				
11	Minimum Corona extinction (kVrms) voltage level of the complete string with corona control ring (Dry Condition)				
12	RIV level of the complete (micro-volts) String with corona control ring at 1 MHz when subjected to a test voltage.				
13	Confirm whether string type tested with offered disc insulator as per IEC				
B.	**INSULATOR**				
1	Manufaturer's Name and address				
2	Applicable Standards				
3	Ultimate Strength				
	a) Complete assembly (kg)				
	b) Suspension / drop clamp (kg)				
C.	**TUBULAR BUS CONDUCTOR**				
1	1.Manufacturer's name and address				
2	2.Applicable Standards				
3	3.Material				
4	**Size of Tubular Bus**				
	i.Standard pipe size- IPS (mm)				
	ii.Outside diameter (mm)				
	iii.Tolerance on outside				

Sl.No.	Description	Offred Data			
		400kV	220kV	72.5kV	33kV
	iv.Thickness (mm)				
	v.Tolerance on Thickness				
5	D.C. Resistance of 20 deg.C				
6	Current rating at ambient temperature of 50 deg. C				
7	Short circuit current rating for 1 sec. duration (kA)				
8	Radio Interference at rated voltage (micro volts)				
9	Weight (kg/m)				
10	Final allowable tubular bus conductor temperature due to short circuit				
D.	**MARSHALLING KIOSK**				
1	Manufacturer's Name and address				
2	Thickness of sheet steel (mm)				
3	Degree of protection provided				
E.	**BUS POST INSULATORS**				
1	Manufacturer's Name and address				
3	Applicable Standards				
4	No. of Units per Stack				
5	Whether corona ring provided or not				
6	Diameter (mm)				
7	Creepage Distance				
	a. Total (mm)				
	b. Protected (mm)				
8	Power Frequency withstand Voltage of Insulator				
	a. One complete stack				
	i. Dry (kV rms)				
	ii. Wet (kV rms)				
9	1.2/50 microsec.impulse withstand Voltage on complete stack (kVp)				
10	250 /2500 micro second switching Surge withstand voltage				
	a.One complete stack				
	i.Dry (kV peak)				

Sl.No.	Description	Offred Data			
		400kV	220kV	72.5kV	33kV
	ii.Wet (kV peak)				
11	Radio interference Voltage of complete stack				
	i.Test Voltage (kVrms)				
	ii. Radio interference voltage (micro volt)				
12	Weight-of complete stack (Kg)				
13	Cantilever Strength of Complete Stack				
15	Torsional Strength(Kg.m)				
16	Compression Strength (Kg)				
17	Confirm whether type tested as per IEC and are in successful operation for at least 2				
F.	**ACSR CONDUCTOR**				
1	Name and address of manufacturer				
2	Standards Applicable				
3	Name & Type of Conductor				
4	No. & diameter of various strands				
5	Overall diameter of the conductor (mm)				
6	Current rating capacity of the Conductor at 75 deg. C (Amps)				
7	Confirm whether type tested as per IEC				
G.	**GALVANISED STEEL EARTHWIRE**				
1.	Name and Address of the Manufacturer				
2.	Standards Applicable				
3.1	UTS of the Earthwire (kN)				
3.2	Lay length of outer steel layer (mm)				
3.3	DC Resistance of earthwire at 20 deg. C (ohms)				
3.4	Standard length of earthwire in the drum (metres)				
3.5	Diameter of earthwire				

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17 630 KVA 33/0.4 kV LT Transformer

SN	Description	Units	Offered Data
1	***Manufacturer***		
1.1	Type	-	
1.2	Class		
2	***Rated data and characteristics***		
2.1	Rated power: - primary/secondary (Rated power at highest tap)	kVA	
2.2	Cooling method	-	
2.3	Rated voltage		
	- HV winding	kV	
	- LV winding	kV	
2.4	Tap changer:		
	- manufacturer	-	
	- model	-	
	- type	-	
	- regulating range	%	
	- rating	A	
2.5	Frequency	Hz	
2.6	Connection of the three-phase windings (group of vectors IEC 60076)	-	
2.7	Rated current at ONAN rated power and rated voltage tap:		
	- HV winding	A	
	- LV winding	A	
2.8	No-load current through:		
	- HV winding	A	
	- LV winding	A	
2.9	Short circuit impedance		
2.9.1	Direct impedance at nominal voltage tap: - HV/LV	%	
2.9.2	Direct impedance at minimum voltage tap: - HV/LV	%	
2.9.3	Direct impedance at maximum voltage tap: - HV/LV	%	
2.9.4	Zero sequence impedance at nominal voltage tap: - HV / LV	%	
2.1	Tolerance to be applied to the short circuit impedance, in terms of % of the guaranteed value on:		
	- nominal voltage tap	%	
	- other taps	%	
2.11	Transformer capacity to withstand external short circuits:		

SN	Description	Units	Offered Data
2.11.1	Short circuit duration	sec	
2.11.2	Symmetrical short circuit current withstand during the indicated period and asymmetrical short circuit withstand:		
	- HV winding	kA RMS kA (peak)	
	- LV winding	kA RMS kA (peak)	
	- pre-fault voltage	p.u.	
2.12	Guaranteed losses		
2.12.1	No-load losses at rated voltage and frequency, with rated voltage tap (design calculation sheet shall be submitted with the bid) corrected to 75 deg. C Wdg. Temp	kW	
2.12.2	No-load losses at 110% of the rated voltage, at rated frequency and rated voltage tap corrected to 75 deg. C Wdg. Temp (kW)	kW	
2.12.3	Tolerance to be applied to no-load losses (in % of the guaranteed value)	%	
2.12.4	Load losses at rated voltage and frequency, with rated voltage tap and ONAN rating corrected to 75 deg. C Wdg. Temp (kW)	kW	
2.12.5	Auxiliary losses at rated voltage and frequency, with rated voltage tap and ONAN rating corrected to 75 deg. C Wdg. Temp (kW)	kW	
2.12.6	Tolerance to be applied to total losses (in %of the guaranteed value) for all the windings	%	
2.13	Highest voltage for equipment:		
	- HV winding	kV	
	- LV winding	kV	
2.14	Rated insulation level:		
2.14.1	Short time power frequency withstand:		
	- HV winding - line terminal	kV RMS	
	- LV winding - line terminal	kV RMS	
	- neutral	kV RMS	
2.14.2	Basic impulse level:		
	- HV winding - line terminal	kV (peak)	
	- LV winding - line terminal	kV (peak)	
	- neutral point	kV (peak)	

SN	Description	Units	Offered Data
2.15	Temperature rise limits at maximum power output ratings and at lowest voltage tap and corresponding voltage:		
	- average winding at ambient temperature	oC	
	- top oil at ambient temperature	oC	
2.16	Permissible overload in emergency cases:		
	- permanent permissible overload based on highest winding temperature which exceeds by 5oC the guaranteed limit	kVA	
	- permanent permissible overvoltage based on the maximum top oil temperature which exceeds by 5oC the guaranteed limit at rated power (in % of the rated voltage)	%	
2.17	Audible noise level		
	- Voltage in percent of rated value	%	
	- ONAN rating	dB(A)	
2.18	Radio Interference Voltage at 0.5 MHz as per IEC 60694	uV	
2.19	Core:		
	- manufacturer	-	
	- grade and thickness of core steel	grade/mm	
	- standard	-	
	- data sheet attached	-	
2.2	Oil:		
	- manufacturer	-	
	- type	-	
	- standard	-	
	- data sheet attached	-	
2.21	Tank /corrugated wall and radiators		
2.21.1	Tank/corrugated wall :		
	- manufacturer	-	
	- thickness		
	- cover	mm	
	- side/corrugated wall	mm	
	- bottom	mm	
2.21.2	Radiator :		
	- manufacturer	-	
	- cooler tube thickness	mm	
	- pressed-sheet radiator thickness	mm	
2.21.3	Safe withstand vacuum at sea level	kPa	
2.22	Bushings		
2.22.1	HV bushings:		
	- class	kV	
	- manufacturer	-	

SN	Description	Units	Offered Data
	- type designation	-	
	- rated current	A	
	- short circuit withstand	kA RMS	
	- basic insulation level	kV (peak)	
	- power frequency withstand for 1 minute	kV RMS	
	- terminal connector for conductor size	mm2	
	- creepage distance	mm	
2.22.2	LV bushings:		
	- class	kV	
	- manufacturer	-	
	- type designation	-	
	- rated current	A	
	- short circuit withstand	kA RMS	
	- basic insulation level	kV (peak)	
	- power frequency withstand for 1 minute	kV RMS	
	- terminal connector for conductor size	mm2	
	- creepage distance	mm	
2.22.3	Neutral bushings:		
	- class	kV	
	- manufacturer	-	
	- type designation	-	
	- rated current	A	
	- short circuit withstand	kA RMS	
	- basic insulation level	kV (peak)	
	- power frequency withstand for 1 minute	kV RMS	
	- terminal connector for conductor size	mm2	
	- creepage distance	mm	
3	***Design data:***		
3.1	Core Design		
	- core type	core or shell	
	- number and length of limbs	no/mm	
	- core diameter	mm	
3.1.1	Core cross section area		
	- wound limbs	mm2	
	- yoke	mm2	
	- unwound limbs	mm2	
3.1.2	Distance between core limb center	mm	
3.1.3	Maximum flux density in the wound limb at:		
	- rated voltage	tesla	
	- 110% of the rated voltage	tesla	
3.1.4	Maximum flux density in the yokes at:		

SN	Description	Units	Offered Data
	- rated voltage	tesla	
	- 110% of the rated voltage	tesla	
3.1.5	Voltage per turn at the above flux density		
	- rated voltage	V	
	- 110% of the rated voltage	V	
3.1.6	Magnetizing current, at rated frequency, on principal tapping, in percent of rated current at maximum HV rating	%	
	- at 90% of the rated voltage	%	
	- at 100% of the rated voltage	%	
	- at 110% of the rated voltage		
3.1.7	Specific loss of core at maximum flux density	W/kg	
3.1.8	Maximum current density in winding;		
	- HV	A/mm2	
	- LV	A/mm2	
3.2	Winding Design		
3.2.1	Winding resistance:		
	- HV winding	ohms	
	- winding conductor	-	
	- Inside diameter of winding coil	m	
	- Outside diameter of winding coil	m	
	- Number of winding turn at normal tap	turns	
	- Cross-section area of winding conductor	mm2	
	- number and width of support spacers per turn	-	
	- total conductor mass	kg	
	- dry insulation mass	kg	
	- LV winding	ohms	
	- winding conductor	-	
	- Inside diameter of winding coil	m	
	- Outside diameter of winding coil	m	
	- Number of winding turn at normal tap	turns	
	- Cross-section area of winding conductor	mm2	
	- number and width of support spacers per turn	-	
	- total conductor mass	kg	
	- dry insulation mass	kg	

SN	Description	Units	Offered Data
3.3	Voltage regulation at ONAN rating and rated voltage tap (in % of the rated voltage):		
	- with unity power factor:		
	- with 0.9 power factor (lagging):	%	
	- with 0.8 power factor (lagging):	%	
4	***Weights and dimensions***		
4.1	Total weight of transformer, equipped for service	kg	
4.2	Weight:		
	- oil	kg	
	- core and coil assembling	kg	
	- tank and accessories	kg	
	- net copper	kg	
	- net core steel	kg	
4.3	Outline dimensions:		
	- length	mm	
	- width	mm	
4.4	Layout drawing no.	-	
5	***Standards***		
5.1	Manufacturing	-	
5.2	Quality assurance	-	
5.3	Type test certification	-	
	(shall be submitted with the bid for approval otherwise it will be assumed that no type tests for identical units are available)		
6	***Installation***	-	

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18	GIS Equipments		
S.N	Parameters:	Unit	Offered Data
A	Complete GIS Module		
1	Nominal voltage of system	kV	
2	Rated voltage of system	kV	
3	Rated voltage for equipment (*U* r)	kV	
4	Rated insulation levels phase-to-earth and between phases		
5	Rated short-duration power-frequency withstand voltage (Ud)	kV	
5	Rated switching impulse withstand voltage (Us)		
i	Phase-to-earth	kV	
ii	Between phases	kV	
6	Rated lightning impulse withstand voltage (Up)	kV	
7	Rated frequency (fr)	Hz	
8	Rated normal current (Ir)	A	
9	Rated short-time withstand current (Ik)	kA	
10	Rated peak withstand current (Ip) (kA)	kA	
11	Rated duration of short-circuit (tk) (s)	S	
12	Rated supply voltage of closing and opening devices and of auxiliary and control circuits (Ua)	V	
13	Rated supply frequency of closing and opening devices and of auxiliary circuits	50 Hz or 60 Hz	
14	Neutral earthing Solidly or not solidly		
15	Number of phases		
16	Single- or three-phase design		
17	Maximum SF6 leakage rate	% / year	
18	Rated filling pressure *p* r		
	Circuit-breaker		
	Other compartments		
19	Alarm pressure *p* a		
	Circuit-breaker		
	Other compartments		
20	Minimum functional pressure *p* m		
	Circuit-breaker		
	Other compartments		
21	Design pressure of enclosures		
	Circuit-breaker		
	Other compartments		
22	Type test pressure of enclosures		
	Circuit-breaker		
	Other compartments		
23	Routine test pressure of enclosures		
	Circuit-breaker		
	Other compartments		
24	Operating pressure of pressure relief device		
	Circuit-breaker		
	Other compartments		
25	Internal fault		
	Short-circuit current	kA	

S.N	Parameters:	Unit	Offered Data
26	Quantity of SF6 gas of complete GIS at filling pressure	Kg	
27	Quantity of SF6 gas of the largest compartment at filling pressure	Kg	
28	Maximum permissible gas dew point	°C	
29	Number of gas compartments		
30	Length of longest section for transportation	m	
31	Weight of the heaviest piece of equipment to be handled during installation on-site	Kg	
B	**Bus ducts**		
1	Inductance	H/m	
2	Capacitance	pF/m	
3	Resistance of enclosure at fr	Ω/m	
4	Resistance of conductor at fr	Ω/m	
5	Surge impedance	Ω	
C	**Bushing (Outdoor-immersed bushing)**		
1	Type of internal insulation		
2	Type of external insulation		
3	Nominal specific creepage distance	mm/kV	
4	Shed profile	Normal or alternating	
5	Rated short-duration, power-frequency withstand voltage (Ud)	kV	
6	Rated switching impulse withstand voltage (Us)	kV	
7	Rated lightning impulse withstand voltage (Up)	kV	
8	Cantilever test load	N	
9	Cantilever operation load	N	
10	Type of line termination		

Note: Bidders shall provide the additional details of the offered equipments in line with Technical Specifications

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19	**COMMUNICATION SYSTEMS**	
SN	**Parameters:**	**Offered Data**
A	**SDH Equipments**	
1	Make	
2	Type	
3	SDH hierarchy level:	
	Capacity Aggregate Bit-rate:	
	CEPT E-1 Ports:	
4	Minimum No. of protected (MSP) directions	
5	No. of E1 ports in E1tributarycards	
6	No. of ethemet ports in Ethemet interface tributary cards	
7	Service Channel provision	
	a) Voice Channel	
	b) Data Channel	
8	Power Supply cards of SDH equipment	
9	Common Control Card of SDH equipment	
B	**Primary Multiplexer/Drop & Insert Multiplexer**	
1	Make	
2	Type	
4	Output Aggregate Rate	
5	Interface Code	
6	Impedance	
7	Maximum Insertion Loss	
8	Power Supply card of multiplexer	

Note: Bidders shall provide the additional details of the offered equipments in line with Technical Specifications

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Chapter 23- Drawings

LIST OF DRAWINGS

S. No.	DRAWING NO.	TITLE
A)	**400/220kV Hetauda Substation**	
1.	NEA-HDI-H-SLD-01 OF 01	Hetauda 400/220 kV GIS Substation Single Line Diagram.
2.	NEA-HDI-H-E-LY-01 OF 01	Electrical Layout Plan of 400 KV GIS Hetauda Substation.
3.	NEA-HDI-H/I-PEB-01 OF 01	GIS Building General Layout.
4.	NEA-HDI-H/I-CT-01 OF 05 (1 to 5)	Detail for cable trench sections.
5.	NEA-HDI-H/I-01 OF 02 (1 to 2)	Detail for drain sections.
6.	NEA-HDI-H/I-FEN-01 OF 01	Standard details for switch yard chain link fencing.
7.	NEA-HDI-H-CR-01 OF 01	RCC Control Building General Layout.
8.	NEA-HDI-H-RCC-DR-01 OF 01	Existing RCC Drain, Hume Pipe and Purposed RCC Drain For Hetauda Substation.
9.	NEA-HDI-H/I-CM-01 OF 01	Communication Connectivity Diagram
B)	**400/220kV Inaruwa Substation**	
1.	NEA-HDI-I-SLD-01 OF 01	Inaruwa 400/220 kv GIS Substation Single Line Diagram.
2.	NEA-HDI-I-E-LY-01 OF 01	Electrical Layout Plan of 400 KV GIS Inaruwa Substation.
3.	NEA-HDI-H/I-PEB-01 OF 01	GIS Building General Layout
4.	NEA-HDI-H/I-CT-01 OF 05 (1 to 5)	Detail for cable trench sections
5.	NEA-HDI-H/I-01 OF 02 (1 to 2)	Detail for drain sections
6.	NEA-HDI-H/I-FEN-01 OF 01	Standard details for switch yard chain link fencing
7.	NEA-HDI-H/I-CM-01 OF 01	Communication Connectivity Diagram
C)	**Existing Drawings**	
1.	HTD-SS-E-01(02)	Electrical layout plan of Hetauda Substation
2.	HTD-SS-E-01(01)	Single line diagram of Hetauda Substation
3.	HTD-SS-E-01(03)	Electrical layout section diagram of Hetauda Substation
4.	IRW-SS-E-01(02)	Electrical layout plan of Inaruwa Substation
5.	IRW-SS-E-01(01)	Single line diagram of Inaruwa Substation
6.	IRW-SS-E-01(03)	Electrical layout section diagram of Inaruwa Substation(220kv)
7.	IRW-SS-E-01(04)	Electrical layout section diagram of Inaruwa Substation(132 and 32 kV)