NEPAL ELECTRICITY AUTHORITY

(An Undertaking of Government of Nepal)
Project Management Directorate

KHIMTI-BARHABISE-LAPSIPHEDI 400 KV SUBSTATION PROJECT

A component of
SASEC Power Transmission and Distribution System Strengthening Project

BIDDING DOCUMENT
FOR

Procurement of Plant
for
Design, Supply, Installation and Commissioning of 400 kV Gas insulated Substations (GIS) at New Khimti, Barhabise and Lapsiphedi

Single-Stage, Two-Envelope
Bidding Procedure

Issued on:	**21 May 2019**
Invitation for Bids No.:	**PMD/ PTDSSP /KBL-075/76-01**
OCB No.:	**PMD/ PTDSSP /KBL-075/76-01**
Employer:	**Nepal Electricity Authority**
Country:	**Nepal**

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Khimti-Barhabise-Lapsiphedi 400 kV Substation Project
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Vol II
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CHAPTER – 1

PROJECT SPECIFIC REQUIREMENTS (PSR)

1.0 PROJECT DESCRIPTION AND SCOPE

1.1 GENERAL

Nepal Electricity Authority (NEA) is establishing three 400 kV GIS Substations with extension of existing/under construction 220 kV GIS substations at Khimti,Ramechap district, Barhabise, Sindhupalchowk district and Lapsiphedi, Kathmandu district of Nepal under Khimti-Barhabise-Lapsiphedi 400 kV Substation Project. The above project is being implemented by Nepal Electricity Authority funded from Asian Development Bank & Government of Nepal.

1.2 NEA is taking up the following works under Khimti-Barhabise-Lapsiphedi 400 kV Substation Project **:**

At New Khimti substation:–

i. Expansion of 400kV **New Khimti** Substation

At Barhabise substation:–

i. Expansion of 400kV **Barhabise** Substation

At Lapsiphedi substation:–

i. Expansion of 400kV **Lapsiphedi** Substation

1.3 Associated Transmission system:

The following transmission lines associated with substation under Tamakoshi(Khimti)-Kathmandu 220/400 KV Transmission Line Project are as below:-

i. New Khimti – Barhabise 400 kV Double Circuit Transmission Line: 45 km (along with OPGW)

ii. Barhabise - Lapsiphedi 400 kV Double Circuit Transmission Line: 44 km (along with OPGW)

1.4 SCOPE

The scope of this specification covers the following:

New Khimti Substation

A. Construction of a new 400 (GIS)/220(GIS) substation at new Khimti 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, 5000 A, 50 kA short circuit rating for 1 sec. and involves installation of following number of Bays):

i. 2 nos. of 400 kV Bays to terminate 400 kV D/C Quad Moose ACSR lines from Barhabise.

ii. 2 nos. bays for connecting each bank of 315 MVA, 400/220 kV Auto Transformers formed with 4 numbers (400/√3)/(220/√3/33) kV,105 MVA, single phase auto transformers with one number unit as spare (under construction 220 kV line bays shall be use for 220 kV side ICT bays) along with supply and installation of autotransformers. Supply & Installation of 4 x 105 MVA Autotransformers is under present scope and 3 x 105 MVA shall be connected in future

Barhabise Substation

A. Construction of a new 400 (GIS)/220(GIS) substation at Barhabise 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, 5000 A, 50 kA short circuit rating for 1 sec. and involves installation of following number of Bays):

i. 2 nos. Bays to terminate 400 kV D/C Quad Moose ACSR lines from New Khimti.

ii. 2 nos. Bays to terminate 400 kV D/C Quad Moose ACSR lines from Lapsiphedi.

iii. 2 nos. bays for connecting each bank of 160 MVA, 400/220 kV Auto Transformers formed with 4 numbers(400/√3)/(220/√3/33) kV,53.33 MVA, single phase auto transformers with one number unit as spare (under construction 220 kV line bays shall be use for 220 kV side ICT bays) along with supply and installation of autotransformers. Supply & Installation of 4 x 53.33 MVA Autotransformers is under present scope and 3 x 105 MVA shall be connected in future.

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

Lapsiphedi Substation

A. Construction of a new 400 (GIS)/220(GIS) substation at Lapsiphedi 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, 5000 A, 50 kA short circuit rating for 1 sec. and involves installation of following number of Bays):

i. 2 nos. Bays to terminate 400 kV D/C Quad Moose ACSR lines from Barhabise.

ii. 2 nos. Spare Bays to terminate 400 kV D/C Quad Moose ACSR lines.

iii. 2 nos. bays for connecting each bank of 160 MVA, 400/220 kV Auto Transformers formed with 4 numbers (400/√3)/(220/√3/33)kV,53.33 MVA, single phase auto transformers with one number unit as spare (existing 220 kV line bays shall be use for 220 kV side ICT bays) along with supply and installation of autotransformers. Supply & Installation of 4 x 53.33 MVA Autotransformers is under present scope and 3 x 105 MVA shall be connected in future.

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

1.5.1 400kV New Khimti GIS Substation

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

A1) <u>400 KV GIS</u>

The 420 kV SF6 gas insulated switch gear shall have one and a half breaker bus bar arrangement. The Switchgear (50 Hz) shall be complete with all necessary terminal boxes, SF6 gas filling, interconnecting power and control wiring, grounding connections, gas monitoring equipment and piping, support structures complete in all respects and consisting of following major items.

A1.1) 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:

a) 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.

b) Three Nos. 1-phase, inductive potential transformers, complete with isolator switch.

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

d) One Bay Module Control Cabinet/ Local Control Cubicle for Bus Bar system.

e) Interface module (under present scope) with the Isolating link for future extension of Bus bar module (on one side). As GIS is likely to be extended in future, the contractor shall make available all details such as cross section, gas pressure etc. required to design adopted in future for extension of GIS, during detailed engineering stage.

f) 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.

A1.2) 420kV, 50KA for 1 sec., SF6 gas insulated metal enclosed **Line feeder bay module**, each set comprising of:-

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

b) Three Nos. 1-phase, 4000A, 6-core, multi ratio, current transformers duly distributed on both side of circuit breaker as per single line diagram.
c) Three Sets of three-phase, 4000A, group-operated disconnectors with safety grounding switch, each complete with manual and motor driven operating mechanism.
d) One Set of three-phase group operated high speed grounding switch complete with manual and motor driven operating mechanism.
e) Three Nos. 1-phase, inductive potential transformers, complete with isolator switch.
f) Three Nos. 1-phase, 4000A, SF6 ducts inside the GIS hall (up to the outer edge of the wall of GIS Hall).
g) One Bay Module Control Cabinet including Bay Controller (Local Control Cubicle).
h) 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.

A1.3) 400kV, 50kA for 1 sec, SF6 gas insulated metal enclosed **Auto Transformer bay module**, each set comprising of :-

a) One set of three single-phase (isolated), 2000A, SF6 gas insulated circuit breaker with control switching device, complete with operating mechanism.
b) Three Nos. 1-phase, 4000A, 6-core, multi ratio, current transformers duly distributed on both side of circuit breaker as per single line diagram.
c) Three Sets of three-phase, 2000A group operated disconnector with safety grounding switch complete with manual and motor driven operating mechanism.
d) One Set of three-phase group operated high speed grounding switch complete with manual and motor driven operating mechanism.
e) Three Nos. 1-phase, 2000A, SF6 ducts inside the GIS hall (up to the outer edge of the wall of GIS Hall).
f) One Bay Module Control Cabinet including Bay Controller (Local Control Cubicle).
g) 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.

A1.4) 420kV, 50kA for 1 second, SF6 gas insulated metal enclosed **Tie bay module (For Lines Bays)** comprising of:-

a) One set of three single-phase (isolated), 4000A, SF6 insulated circuit breaker complete with separate operating mechanism for each pole.
b) Three Nos. 1-phase, 4000A, 6-core, multi ratio, current transformers duly

distributed on both side of circuit breaker as per single line diagram.

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

d) Two sets 3-phase, group operated safety-grounding switches, complete with manual and motor driven operating mechanisms.

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

f) 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.

A1.5) 420kV, 50kA for 1 second, SF6 gas insulated metal enclosed **Tie bay module (For Auto Transformers Bays)** comprising of:-

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

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

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

d) Two sets 3-phase, group operated safety-grounding switches, complete with manual and motor driven operating mechanisms.

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

f) 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) 400 kV, 4000A/2000A, 50 kA for 1Sec, Three 1-Phase (isolated**) SF6 gas ducts** (including support structures, gas monitoring devices, gas barrier, pressure switch, UHF PD sensor) from outside (i.e. wall surface) of the GIS building to center line of SF6/Air Bushing shall be as per BPS. SF6 gas Ducts inside GIS hall are part of GIS Module.

Multi-Tier GIS Bus ducts shall be used, as per requirements to be determined during detailed engineering, considering site constraints and layout arrangement. All present and future line bays shall be properly accommodated within available switchyard area with provision for personnel and equipments movements and maintenance.

4) 400 kV SF6/air bushings of GIS bay along with terminal connectors & support structure for outdoor connections to connect GIS with overhead lines/equipments.

5) 220 kV (220 kV single or twin, 1C 1200 mm2) XLPE Cables along with accessories and Cable sealing for interconnection of 220 kV side of 400/220 kV Transformer with existing 220 kV GIS lines bays to be used as 220 kV ICT bays. SF6 to Cable Bushing and cable termination is under the present scope of work.

6) During Detail 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/outgoing 400 kV lines Bays (From Barhabise) is supposed to be charged at 220 kV Voltage level at under construction 220/132 kV New Khimti Substation. Under present scope of the contract, same 400 kV lines shall be terminated in 400 kV bays and the under construction 220 kV GIS lines bays shall be used as 220 kV ICT bays. The 220 kV Bus bar scheme is Double Main 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) 245 kV, 2000A, 40 kA for 1Sec, Three 1-Phase (isolated) **SF6 Gas insulated Bus Duct (GIB)** with support structure (along with Gas monitoring devices, barriers, pressure switches, UHF based Partial Discharge measurement Sensors etc. as required) for connecting 220 kV side of 400/220kV Transformer to the existing 220 kV Lines bays as ICT bays feeder.

9) 220 kV SF6/air bushings and SF6/cable bushings of GIS bay along with terminal connectors & support structure for outdoor connections to connect GIS with equipments.

10) Supply, Erection, testing & commissioning of **4X105 MVA, 400/√3/220/√3/33kV ,** 1-Phase Auto Transformer (One bank + One Spare) including all materials/fittings/accessories/Digital RTCC panel/Common MB/Individual MB, *Control cabinet/cooling control cabinets*, Cables including special cable (if any), & loading arrangement, both Neutral (HV & IV) formations etc. The scope also includes supply of transformer bushing end terminal connectors suitable for GIS ICT Bay both for 400 kV and 220 kV sides of Transformer complete in all respect for the above mentioned auto transformers.

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

12) 400 kV, 220kV, 72.5 and 33 kV Bus Post Insulators, 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.

13) Augmentation and Extension of sub-station automation system by providing BCUs along with associated equipments including hardware and software for following bays (bay as defined in Technical Specification, Section - Substation Automation). The make of existing SAS shall be provided during detailed Engineering.

- *400kV : 2 Line Bays, 2 ICT Bays & 2 Tie Bays*
- *220 kV : 2 ICT Bays*
- *Auxiliary System: 1 Set*

In the present scope, bidder shall include BCUs required for 400 kV bays including all necessary hardware and software to integrate with the existing Substation Automation System including updation of system database, displays, and development of additional displays and reports as per requirement. The extension of the existing SAS system is under the present scope of the contract. Bidders are requested to visit the substation site and make own acquaint with the scope of works as described herein. The contractor shall also supply necessary BCU for monitoring and control of auxiliary supply including operation of Isolator associated with auxiliary transformer.

14) Digital protection Coupler (suitable for interfacing with E1 port of SDH equipment) and associated power & control Cables, Fibre cables and Accessories for both ends of the following lines:-

Khimti – Barhabise - 400 kV D/C T/l (Currently Charged at 220 kV D/C T/L)

Barhabise – Lapsiphedi -400 kV D/C T/l (Currently Charged at 220 kV D/C T/L)

The Bidder shall also design the Digital Protection Coupler that will communicate next end using separate fiber and only 2 cores of fiber shall be provided for multiple of transmission line. The specification of Digital Protection coupler is attached as **Annexure-II**.

In the present scope of contract, the necessary interfacing of the existing communication system for the integration of 400 kV Lines shall be included. The Bidder shall install Giga-Ethernet cards compatible with existing SDH Equipment installed at **New Khimti** Substation.

15) SAS and 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 unit including spare (if any), are IEC 61850 compliant (either directly or through a Gateway).Those monitoring equipment's 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/48V 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 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 **New Khimti** 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 3 stations. The manufacturer 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 104 as per requirement being provided at **New khimti.** The following 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 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 above as GPS Time stamped.
j) Temperature value per substation.
k) Any other point decided during detailed engineering.

16) Complete relay and protection system for 400kV bays (Line bays and ICT Bays) and 220 kV ICT bays under present scope as per section – Control and Relay panels. Wiring and other necessary arrangements for integration of existing Bus Bar Protection scheme with 220 kV ICT bays is also under present scope.

17) 400kV Surge Arrestors (AIS type).

18) 220kV,72.5kV,33kV Surge Arrestors (AIS type).

19) Fire protection system (HVW spray & hydrant system) for all buildings, **4X105 MVA, 400/√3/220/√3/33kV ,** 1-Phase Auto Transformer (One bank + One Spare) including extension of main water header (available near existing 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) Air Conditioning System for control room cum administrative building, panel room and Ventilation system for GIS hall.

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 exists 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. Measurement of earth resistivity is in the scope of Contractor.

23) Lattice and pipe structures (galvanized): 400 kV Double Dead end Transmission Tower Structure, Standard gantry structures (Beams & Columns) and Equipment support structures 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) 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).

LT switchgear (AC/DC Distribution boards) considering present bays and future bays. Integration of new AC/DC Distribution boards with existing AC/DC Distribution boards (if necessary) is also in present scope of work. The existing AC/DC drawings shall be provided during detail engineering.

27) Batteries & Battery Chargers

28) 1.1 kV grade Power & Control cables along with complete accessories. Auxiliary Power supply and control cables from control room and RTCC panel to common marshalling box of transformer are also in present scope of work.

29) Visual monitoring system required for watch and ward of Substation premises as per **Annexure-IV.**

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

B. Mandatory Spares

Design, engineering, manufacture, testing, and supply including transportation, insurance & storage at site as per **Annexure-I**

C. Civil works - The scope of work shall include but shall not be limited to the following–

C.1 Design, Engineering and civil work (as per Contractor supplied drawings) for:

a) Foundation for GIS Hall Building and duct supporting structures inside the GIS hall.

b) Foundation for GIS bus duct supporting structures (outside the GIS hall), *SF6/Air bushings and SF6/Cable bushings*.

c) Foundation for *400/220 kV Transformers* along with jacking pads, rail track, Oil soak pit, sump pit, pylon support and fire resistant wall (s) as required.

d) GIS Buildings including control room cum administrative building. The size of 400kV GIS Building shall be suitable to accommodate five numbers bays in addition to the maintenance bay. The GIS hall shall be suitable for mounting of EOT crane. The GIS and control room building shall be of Pre-Engineered steel structure as per Section “Civil”.

e) Fire resistant wall between Transformer/Reactors.

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

g) Cable trenches inside GIS hall.

h) Foundations of gantry, equipment support structures and LT Transformers as per BOQ and tender drawings.

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

j) All roads 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 switch yard gates. Dismantling/re-erection of existing fence as per requirement is also included.

m) Layout and details of Water supply and Sewage system.

n) Soil investigation, contouring, leveling and filling. Contouring and site leveling works; The substation area shall be developed in terraces at single or multi levels by cutting and filling. The finished ground level shall be decided during detail engineering based on spot levels and highest flood level if applicable.

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) Any other item/design/drawing for completion of scope of works.

1.5.2 400kV Barhabise GIS Substation

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

A1) 400 KV GIS

The 420 kV SF6 gas insulated switch gear shall have one and a half breaker bus bar arrangement. The Switchgear (50 Hz) shall be complete with all necessary terminal boxes, SF6 gas filling, interconnecting power and control wiring, grounding connections, gas monitoring equipment and piping, support structures complete in all respects and consisting of following major items.

A1.1) 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:

a) 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.
b) Three Nos. 1-phase, inductive potential transformers, complete with isolator switch.

c) One No. 3-phase, group operated safety grounding switch, complete with manual and motor driven operating mechanisms.
d) One Bay Module Control Cabinet/ Local Control Cubicle for Bus Bar system.
e) Interface module (under present scope) with the Isolating link for future extension of Bus bar module (on one side). As GIS is likely to be extended in future, the contractor shall make available all details such as cross section, gas pressure etc. required to design adopted in future for extension of GIS, during detailed engineering stage.
f) 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.

A1.2) 420kV, 50KA for 1 sec., SF6 gas insulated metal enclosed **Line feeder bay module**, each set comprising of:-

a) One set of three single-phase (isolated), 4000A, SF6 insulated circuit breaker complete with separate operating mechanism for each pole.
b) Three Nos. 1-phase, 4000A, 6-core, multi ratio, current transformers duly distributed on both side of circuit breaker as per single line diagram.
c) Three Sets of three-phase, 4000A, group-operated disconnectors with safety grounding switch, each complete with manual and motor driven operating mechanism.
d) One Set of three-phase group operated high speed grounding switch complete with manual and motor driven operating mechanism.
e) Three Nos. 1-phase, inductive potential transformers, complete with isolator switch.
f) Three Nos. 1-phase, 4000A, SF6 ducts inside the GIS hall (up to the outer edge of the wall of GIS Hall).
g) One Bay Module Control Cabinet including Bay Controller (Local Control Cubicle).
h) 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.

A1.3) 400kV, 50kA for 1 sec, SF6 gas insulated metal enclosed **Auto transformer bay module**, each set comprising of :-

a) One set of three single-phase (isolated), 2000A, SF6 gas insulated circuit breaker with control switching device, complete with operating mechanism.
b) Three Nos. 1-phase, 4000A, 6-core, multi ratio, current transformers duly distributed on both side of circuit breaker as per single line diagram.
c) Three Sets of three-phase, 2000A group operated disconnector with safety grounding switch complete with manual and motor driven operating mechanism.

d) One Set of three-phase group operated high speed grounding switch complete with manual and motor driven operating mechanism.
e) Three Nos. 1-phase, 2000A, SF6 ducts inside the GIS hall (up to the outer edge of the wall of GIS Hall).
f) One Bay Module Control Cabinet including Bay Controller (Local Control Cubicle).
g) 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.

A1.4) 420kV, 50KA for 1 sec., SF6 gas insulated metal enclosed **Bus shunt reactor module** , each set comprising of:-

a) One set of three single-phase (isolated), 4000A, SF6 insulated circuit breaker complete with control switching device, complete with operating mechanism.
b) Three Nos. 1-phase, 4000A, 6-core, multi ratio, current transformers duly distributed on both side of circuit breaker as per single line diagram.
c) Three Sets of three-phase, 4000A, group-operated disconnectors with safety grounding switch, each complete with manual and motor driven operating mechanism.
d) One Set of three-phase group operated high speed grounding switch complete with manual and motor driven operating mechanism.
e) Three Nos. 1-phase, 4000A, SF6 ducts inside the GIS hall (up to the outer edge of the wall of GIS Hall).
f) One Bay Module Control Cabinet including Bay Controller (Local Control Cubicle).
g) 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.

A1.5) 420kV, 50kA for 1 second, SF6 gas insulated metal enclosed **Tie bay module** (For Lines Bays and Shunt Reactors Bays) comprising of:-

a) One set of three single-phase (isolated), 4000A, SF6 insulated circuit breaker complete with separate operating mechanism for each pole.
b) Three Nos. 1-phase, 4000A, 6-core, multi ratio, current transformers duly distributed on both side of circuit breaker as per single line diagram.
c) Two sets 3-phase, 4000A, group operated isolator switches, complete with manual and motor driven operating mechanisms.
d) Two sets 3-phase, group operated safety-grounding switches, complete with manual and motor driven operating mechanisms.
e) One Bay Module Control Cabinet including Bay Controller (Local Control Cubicle).

f) 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.

A1.6) 420kV, 50kA for 1 second, SF6 gas insulated metal enclosed **Tie bay module** (For Auto Transformers Bays) comprising of:-

a) One set of three single-phase (isolated), 2000A, SF6 insulated circuit breaker complete with operating mechanism.
b) Three Nos. 1-phase, 4000A, 6-core, multi ratio, current transformers duly distributed on both side of circuit breaker as per single line diagram.
c) Two sets 3-phase, 2000A, group operated isolator switches, complete with manual and motor driven operating mechanisms.
d) Two sets 3-phase, group operated safety-grounding switches, complete with manual and motor driven operating mechanisms.
e) One Bay Module Control Cabinet including Bay Controller (Local Control Cubicle).
f) 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) 400 kV, 4000A/2000A, 50 kA for 1Sec, Three 1-Phase (isolated**) SF6 gas ducts** (including support structures, gas monitoring devices, gas barrier, pressure switch, UHF PD sensor) from outside (i.e. wall surface) of the GIS building to center line of SF6/Air Bushing shall be as per BPS. SF6 gas Ducts inside GIS hall are part of GIS Module.
Multi-Tier GIS Bus ducts shall be used, as per requirements to be determined during detailed engineering, considering site constraints and layout arrangement. All present and future line bays shall be properly accommodated within available switchyard area with provision for personnel and equipments movements and maintenance.

4) 400 kV SF6/air bushings of GIS bay along with terminal connectors & support structure for outdoor connections to connect GIS with overhead

lines/equipments.

5) *220 kV (220 kV single or twin, 1C 1200 mm2) XLPE Cables along with accessories and Cable sealing for interconnection of 220 kV side of 400/220 kV Transformer with existing 220 kV GIS lines bays to be used as 220 kV ICT bays. SF6 to Cable Bushing and cable termination is under the present scope of work.*

220 kV(220 kV single or twin, 1C 1200 mm2) XLPE Cables along with accessories and Cable sealing shall also be used for temporary bypassing of existing 220 kV Incoming/outgoing lines from 220 kV DDE tower/takeoff gantry to 220 kV GIS duct outside 220kV GIS hall as 400 kV GIS switchyard/ building area lies directly under the 220kV TL which connect 220kV GIS switchyard to 220kV DDE. SF6 to Cable Bushing and cable termination is under the present scope of work.

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/outgoing 400 kV lines Bays (From New Khimti & Lapsiphedi) is supposed to be charged at 220 kV Voltage level at under construction 220/132 kV Barhabise Substation. Under present scope of the contract, same 400 kV lines shall be terminated in 400 kV bays and the existing 220 kV GIS lines bays shall be used as 220 kV ICT bays. The 220 kV Bus bar scheme is Double Main 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) 245 kV, 2000A, 40 kA for 1Sec, Three 1-Phase (isolated) **SF6 Gas insulated Bus Duct (GIB)** with support structure (along with Gas monitoring devices, barriers, pressure switches, UHF based Partial Discharge measurement Sensors etc. as required) for connecting 220 kV side of 400/220kV Transformer to the existing 220 kV Lines bays as ICT bays feeder.

9) 220 kV SF6/air bushings and SF6/Cable bushings of GIS bay along with terminal connectors & support structure for outdoor connections to connect GIS with equipments.

10) Supply, Erection, testing & commissioning of **4X53.33 MVA, 400/√3/220/√3/33kV ,** 1-Phase Auto Transformer (One bank + One Spare) including all materials/fittings/accessories/Digital RTCC panel/Common MB/Individual MB, Control cabinet/cooling control cabinets, Cables including special cable (if any), & loading arrangement, both Neutral (HV & IV) formations etc. The scope also includes supply of transformer bushing end terminal connectors suitable for GIS ICT Bay both for 400 kV and 220 kV sides of Transformer complete in all respect for the above mentioned auto transformers.

11) Supply, Erection, testing & commissioning of 1 nos. **420kV, 3 Ph., 50 MVAR** Reactors, complete in all respect for the above mentioned Bus Reactor.

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

13) 400 kV, 220kV, 72.5 and 33 kV Bus Post Insulators, 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 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.

14) Augmentation and Extension of sub-station automation system by providing BCUs along with associated equipments including hardware and software for following bays (bay as defined in Technical Specification, Section - Substation Automation). The make of existing SAS shall be provided during detailed Engineering.

- *400kV : 4 Line Bays, 2 ICT Bays, 1 Reactor Bays & 4 Tie Bays*
- *220 kV : 2 ICT Bays Bays*
- *Auxiliary System: 1 Set*

In the present scope, bidder shall include BCUs required for 400 kV bays including all necessary hardware and software to integrate with the existing Substation Automation System including updation of system database, displays, and development of additional displays and reports as per requirement. The extension of the existing SAS system is under the present scope of the contract. Bidders are requested to visit the substation site and make own acquaint with the scope of works as described herein. The contractor shall also supply necessary BCU for monitoring and control of auxiliary supply including operation of Isolator associated with auxiliary transformer.

15) Digital protection Coupler (suitable for interfacing with E1 port of SDH equipment) and associated power & control Cables, Fibre cables and Accessories for both ends of the following lines:-
Khimti – Barhabise - 400 kV D/C T/l (Currently Charged at 220 kV D/C T/L)

Barhabise – Lapsiphedi -400 kV D/C T/l (Currently Charged at 220 kV D/C T/L)

The Bidder shall also design the Digital Protection Coupler that will communicate next end using separate fiber and only 2 cores of fiber shall be provided for multiple of transmission line. The specification of Digital Protection coupler is attached as **Annexure-II**.

In the present scope of contract, the necessary interfacing of the existing communication system for the integration of 400 kV Lines shall be included. The Bidder shall install Giga-Ethernet cards compatible with existing SDH Equipment installed at **Barhabise** Substation.

16) **SAS and 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 unit including spare (if any), are IEC 61850 compliant (either directly or through a Gateway). Those monitoring equipment's 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/48V 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 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 **Barhabise** 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 3 stations. The manufacturer 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 104 as per requirement being provided at **Barhabise.** The following 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 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 above as GPS Time stamped.
j) Temperature value per substation.
k) Any other point decided during detailed engineering.

17) Complete relay and protection system for 400kV bays (Line bays and ICT Bays) and 220 kV ICT bays under present scope as per section –Control and Relay panels. Wiring and other necessary arrangements for integration of existing Bus Bar Protection scheme with 2 no's of 220 kV ICT bays is also under present scope.

18) 400kV Surge Arrestors.(AIS type).

19) 220kV,72.5kV,33kV Surge Arrestors (AIS type).

20) Fire protection system (HVW spray & hydrant system) for all buildings, **4X53.33 MVA, 400/√3/220/√3/33kV, 1-Phase Auto Transformer (One bank + One Spare) and 1nos. 420kV, 50MVAR** Reactors including extension of main water header (available near existing 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) Air Conditioning System for control room cum administrative building, panel room and Ventilation system for GIS hall.

22) 1.1kV grade Power & Control Cable along with complete accessories to complete the scope of works.

23) 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. Measurement of earth resistivity is in the scope of Contractor.

24) Lattice and pipe structures (galvanized): 400 kV Double Dead end Transmission Tower Structure, Standard gantry structures (Beams & Columns) and Equipment support structures shall be prepared by the contractor and put up for approval of NEA during detailed engineering.

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

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) considering present bays and future bays. Integration of new AC/DC Distribution boards with existing AC/DC Distribution boards (if necessary) is also in present scope of work. The existing AC/DC drawings shall be provided during detail engineering.

28) Batteries & Battery Chargers

29) 1.1 kV grade Power & Control cables along with complete accessories. Auxiliary Power supply and control cables from control room and RTCC panel to common marshalling box of transformer are also in present scope of work.

30) Visual monitoring system required for watch and ward of Substation premises as per **Annexure-IV.**

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

B. Mandatory Spares

Design, engineering, manufacture, testing, and supply including transportation, insurance & storage at site as per **Annexure-I**

C. Civil works - The scope of work shall include but shall not be limited to the following–

C.1 Design, Engineering and civil work (as per Contractor supplied drawings) for:

a) Foundation for GIS Hall Building and duct supporting structures inside the GIS hall.

b) Foundation for GIS bus duct supporting structures (outside the GIS hall), *SF6/Air bushings and SF6/Cable bushings*.

c) foundation for *400/220 kV Transformers* and *420kV, 80MVAR Reactors* along with jacking pads, rail track, Oil soak pit, sump pit, pylon support and fire resistant wall (s) as required.

d) GIS Buildings including control room cum administrative building. The size of 400kV GIS Building shall be suitable to accommodate seven numbers bays in addition to the maintenance bay. The GIS hall shall be suitable for mounting of EOT crane. The GIS and control room building shall be of Pre-Engineered steel structure as per Section “Civil”.

e) Fire resistant wall between Transformer/Reactors.

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

g) Cable trenches inside GIS hall.

h) Foundations of gantry, equipment support structures and LT Transformers as per BOQ and tender drawings.

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

j) All roads 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 switch yard gates. Dismantling/re-erection of existing fence as per requirement is also included.

m) Layout and details of Water supply and Sewage system.

n) Soil investigation, contouring, leveling and filling. *Contouring and site leveling works; The substation area shall be developed in terraces at single or multi levels by cutting and filling . The finished ground level shall be decided during detail engineering based on spot levels and highest flood level if applicable*.

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) Any other item/design/drawing for completion of scope of works.

1.5.3 <u>400kV Lapsiphedi GIS Substation</u>

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

A1) <u>400 KV GIS</u>

The 420 kV SF6 gas insulated switch gear shall have one and a half breaker bus bar arrangement. The Switchgear (50 Hz) shall be complete with all necessary terminal boxes, SF6 gas filling, interconnecting power and control wiring, grounding connections, gas monitoring equipment and piping, support structures complete in all respects and consisting of following major items.

A1.1) 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:

a) 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.
b) Three Nos. 1-phase, inductive potential transformers, complete with isolator switch
b) One No. 3-phase, group operated safety grounding switch, complete with manual and motor driven operating mechanisms.
c) One Bay Module Control Cabinet/ Local Control Cubicle for Bus Bar system.
d) Interface module (under present scope) with the Isolating link for future extension of Bus bar module (on one side). As GIS is likely to be extended in future, the contractor shall make available all details such as cross section, gas pressure etc. required to design adopted in future for extension of GIS, during detailed engineering stage.
f) 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.

A1.2) 420kV, 50KA for 1 sec., SF6 gas insulated metal enclosed **Line feeder bay module**, each set comprising of:-

a) One set of three single-phase (isolated), 4000A, SF6 insulated circuit breaker complete with separate operating mechanism for each pole.
b) Three Nos. 1-phase, 4000A, 6-core, multi ratio, current transformers duly distributed on both side of circuit breaker as per single line diagram.
c) Three Sets of three-phase, 4000A, group-operated disconnectors with safety grounding switch, each complete with manual and motor driven operating mechanism.
d) One Set of three-phase group operated high speed grounding switch complete with manual and motor driven operating mechanism.
e) Three Nos. 1-phase, inductive potential transformers, complete with isolator switch.
f) Three Nos. 1-phase, 4000A, SF6 ducts inside the GIS hall (up to the outer edge of the wall of GIS Hall).
g) One Bay Module Control Cabinet including Bay Controller (Local Control Cubicle).
h) 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.

A1.3) 420kV, 50kA for 1 sec, SF6 gas insulated metal enclosed **Auto Transformer bay module**, each set comprising of :-

a) One set of three single-phase (isolated), 2000A, SF6 gas insulated circuit breaker with control switching device, complete with operating mechanism.
b) Three Nos. 1-phase, 4000A, 6-core, multi ratio, current transformers duly distributed on both side of circuit breaker as per single line diagram.
c) Three Sets of three-phase, 2000A group operated disconnector with safety grounding switch complete with manual and motor driven operating mechanism.
d) One Set of three-phase group operated high speed grounding switch complete with manual and motor driven operating mechanism.
e) Three Nos. 1-phase, 2000A, SF6 ducts inside the GIS hall (up to the outer edge of the wall of GIS Hall).
f) One Bay Module Control Cabinet including Bay Controller (Local Control Cubicle).
g) 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.

A1.4) 420kV, 50kA for 1 second, SF6 gas insulated metal enclosed **Tie bay module** (For Lines Bays) comprising of:-

a) One set of three single-phase (isolated), 4000A, SF6 insulated circuit breaker complete with separate operating mechanism for each pole.
b) Three Nos. 1-phase, 4000A, 6-core, multi ratio, current transformers duly distributed on both side of circuit breaker as per single line diagram.
c) Two sets 3-phase, 4000A, group operated isolator switches, complete with manual and motor driven operating mechanisms.
d) Two sets 3-phase, group operated safety-grounding switches, complete with manual and motor driven operating mechanisms.
e) One Bay Module Control Cabinet including Bay Controller (Local Control Cubicle).
f) 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.

A1.5) 420kV, 50kA for 1 second, SF6 gas insulated metal enclosed **Tie bay module** (For Auto Transformers Bays) comprising of:-

a) One set of three single-phase (isolated), 2000A, SF6 insulated circuit breaker complete with operating mechanism.
b) Three Nos. 1-phase, 4000A, 6-core, multi ratio, current transformers duly distributed on both side of circuit breaker as per single line diagram.
c) Two sets 3-phase, 2000A, group operated isolator switches, complete with manual and motor driven operating mechanisms.

d) Two sets 3-phase, group operated safety-grounding switches, complete with manual and motor driven operating mechanisms.

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

f) 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) 400 kV, 4000A/2000A, 50 kA for 1Sec, Three 1-Phase (isolated**) SF6 gas ducts** (including support structures, gas monitoring devices, gas barrier, pressure switch, UHF PD sensor) from outside (i.e. wall surface) of the GIS building to center line of SF6/Air Bushing shall be as per BPS. SF6 gas Ducts inside GIS hall are part of GIS Module.
Multi-Tier GIS Bus ducts shall be used, as per requirements to be determined during detailed engineering, considering site constraints and layout arrangement. All present and future line bays shall be properly accommodated within available switchyard area with provision for personnel and equipments movements and maintenance.

4) 400 kV SF6/air bushings and SF6/Cable bushings of GIS bay along with terminal connectors & support structure for outdoor connections to connect GIS with overhead lines/equipments.

5) *220 kV (220 kV single or twin, 1C 1200 mm2) XLPE Cables along with accessories and Cable sealing for interconnection of 220 kV side of 400/220 kV Transformer with existing 220 kV GIS lines bays to be used as 220 kV ICT bays. SF6 to Cable Bushing and cable termination is under the present scope of work.*

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/outgoing 400 kV lines Bays (From Barhabise) is supposed to be charged at 220 kV Voltage level at under construction 220/132 kV **Lapsiphedi**

Substation. Under present scope of the contract, same 400 kV lines shall be terminated in 400 kV bays and the existing 220 kV GIS lines bays shall be used as 220 kV ICT bays. The 220 kV Bus bar scheme is Double Main 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) 245 kV, 2000A, 40 kA for 1Sec, Three 1-Phase (isolated) **SF6 Gas insulated Bus Duct** (GIB) with support structure (along with Gas monitoring devices, barriers, pressure switches, UHF based Partial Discharge measurement Sensors etc. as required) for connecting 220 kV side of 400/220kV Transformer to the existing 220 kV Lines bays as ICT bays feeder.

9) 220 kV SF6/air bushings and SF6/Cable bushings of GIS bay along with terminal connectors & support structure for outdoor connections to connect GIS with equipments.

10) Supply, Erection, testing & commissioning of **4X53.33 MVA, 400/√3/220/√3/33kV ,** 1-Phase Auto Transformer (One bank + One Spare) including all materials/fittings/accessories/Digital RTCC panel/Common MB/Individual MB, Control cabinet/cooling control cabinets, Cables including special cable (if any), & loading arrangement, both Neutral (HV & IV) formations etc. The scope also includes supply of transformer bushing end terminal connectors suitable for GIS ICT Bay both for 400 kV and 220 kV sides of Transformer complete in all respect for the above mentioned auto transformers.

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

12) 400 kV, 220kV, 72.5 and 33 kV Bus Post Insulators, 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.

13) Augmentation and Extension of sub-station automation system by providing BCUs along with associated equipments including hardware and software for following bays (bay as defined in Technical Specification, Section - Substation Automation). The make of existing SAS shall be provided during detailed Engineering.

- *400kV : 4 Line Bays, 2 ICT Bays, & 3 Tie Bays*
- *220 kV : 2 ICT Bays*
- *Auxiliary System: 1 Set*

In the present scope, bidder shall include BCUs required for 400 kV bays including all necessary hardware and software to integrate with the existing Substation Automation System including updation of system database, displays, and development of additional displays and reports as per requirement. The extension of the existing SAS system is under the present scope of the contract. Bidders are requested to visit the substation site and make own acquaint with the scope of works as described herein. The contractor shall also supply necessary BCU for monitoring and control of auxiliary supply including operation of Isolator associated with auxiliary transformer.

14) Digital protection Coupler (suitable for interfacing with E1 port of SDH equipment) and associated power & control Cables, Fibre cables and Accessories for both ends of the following lines:-

Khimti – Barhabise - 400 kV D/C T/l (Currently Charged at 220 kV D/C T/L)

Barhabise – Lapsiphedi -400 kV D/C T/l (Currently Charged at 220 kV D/C T/L)

The Bidder shall also design the Digital Protection Coupler that will communicate next end using separate fiber and only 2 cores of fiber shall be provided for multiple of transmission line. The specification of Digital Protection coupler is attached as **Annexure-II**.

In the present scope of contract, the necessary interfacing of the existing communication system for the integration of 400 kV Lines shall be included. The Bidder shall install Giga-Ethernet cards compatible with existing SDH Equipment installed at **Lapsiphedi** Substation.

15) SAS and 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 unit including spare (if any), are IEC 61850 compliant (either directly or through a Gateway). Those monitoring equipment's 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/48V 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 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 **Lapsiphedi** 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 3 stations. The manufacturer 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 104 as per requirement being provided at **Lapsiphedi.** The following List of IO Points to be transmitted to LDC Kathmandu:

l) MW and MVAR for all lines , transformers, reactors and Capacitors
m) Voltage of all buses
n) Frequency of 400kV Bus
o) All Breakers
p) All isolators
q) Tap Position for all transformers
r) Master protection signal for all feeders, transformers Units and Bus Bar
s) Loss of Voltage signal for Bus bar
t) All the points identified above as GPS Time stamped.
u) Temperature value per substation.
v) Any other point decided during detailed engineering.

16) Complete relay and protection system for 400kV bays (Line bays and ICT Bays) and 220 kV ICT bays under present scope as per section – Control and Relay panels. Wiring and other necessary arrangements for integration of existing Bus Bar Protection scheme with 220 kV ICT bays is also under present scope.

17) 400kV Surge Arrestors (AIS type).

18) 220kV,72.5kV,33kV Surge Arrestors (AIS type).

19) Fire protection system (HVW spray & hydrant system) for all buildings, **4X53.33 MVA, 400/√3/220/√3/33kV ,** 1-Phase Auto Transformer (One bank + One Spare) including extension of main water header (available near existing 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) Air Conditioning System for control room cum administrative building, panel room and Ventilation system for GIS hall.

21) Insulator strings and hardware, clamps & connectors, terminal connectors (including terminal connectors for Transformer and Reactors), conductor, earth wire and earthing materials, spacers, cable supporting angles/channels, cable trays & covers, Junction box, buried cable trenches etc. as required.

22) 1.1kV grade Power & Control Cable along with complete accessories to complete the scope of works.

23) 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. Measurement of earth resistivity is in the scope of Contractor.

24) Lattice and pipe structures (galvanized): 400 kV Double Dead end Transmission Tower Structure, Standard gantry structures (Beams & Columns) and Equipment support structures shall be prepared by the contractor and put up for approval of NEA during detailed engineering.

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

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) considering present bays and future bays. Integration of new AC/DC Distribution boards with existing AC/DC Distribution boards (if necessary) is also in present scope of work. The existing AC/DC drawings shall be provided during detail engineering.

28) Batteries & Battery Chargers

29) 1.1 kV grade Power & Control cables along with complete accessories. Auxiliary Power supply and control cables from control room and RTCC panel to common marshalling box of transformer are also in present scope of work.

30) Visual monitoring system required for watch and ward of Substation premises as per **Annexure-IV.**

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

B) Mandatory Spares –

Design, engineering, manufacture, testing, and supply including transportation, insurance & storage at site as per **Annexure-I**

C. Civil works - The scope of work shall include but shall not be limited to the following–

C.1 Design, Engineering and civil work (as per Contractor supplied drawings) for:

a) Foundation for GIS Hall Building and duct supporting structures inside the GIS hall.

b) Foundation for GIS bus duct supporting structures (outside the GIS hall), *SF6/Air bushings and SF6/Cable bushings*.

c) foundation for *400/220 kV Transformers* along with jacking pads, rail track, Oil soak pit, sump pit, pylon support and fire resistant wall (s) as required.

d) GIS Buildings including control room cum administrative building. The size of 400kV GIS Building shall be suitable to accommodate five numbers bays in addition to the maintenance bay. The GIS hall shall be suitable for mounting of EOT crane. The GIS and control room building shall be of Pre-Engineered steel structure as per Section "Civil".

e) Fire resistant wall between Transformer/Reactors.

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

g) Cable trenches inside GIS hall.

h) Foundations of gantry, equipment support structures and LT Transformers as per BOQ and tender drawings.

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

j) All roads 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 switch yard gates.

Dismantling/re-erection of existing fence as per requirement is also included.

m) Layout and details of Water supply and Sewage system.

n) Soil investigation, contouring, leveling and filling. *Contouring and site leveling works; The substation area shall be developed in terraces at single or multi levels by cutting and filling. The finished ground level shall be decided during detail engineering based on spot levels and highest flood level if applicable*.

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) Any other item/design/drawing for completion of scope of works.

2.0 The Bidders are advised to visit the substation sites *at New Khimti, Barhabise & Lapsiphedi* 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 for 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.

2.1 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 bidder. 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

2.2 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.

2.3 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, firef ighting protection and 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.

2.4 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.

3.0 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

4.0 PHYSICAL AND OTHER PARAMETERS

4.1 Location of the Substation

The substations (New Khimti, Barhabise & Lapsiphedi) of Nepal Electricity Authority are located in the North-Eastern part of Nepal.

4.1 Meteorological data :-

S.No.	Description	New Khimti	Barhabise	Lapsiphedi
i)	Max. ambient air temperature (°C)	45	45	45

ii)	Minimum ambient air temperature (°C)	0	-5.5	0
iii)	Altitude (above M.S.L.) (mtrs)	662	1190	1420
iv)	Relative humidity - Maximum	100	100	100
v)	Relative humidity - Minimum	20	20	20
vi)	Amount of snow fall (mm) 0	0	0	0
vii)	Wind speed	47m/s	47m/s	47m/s
viii)	Siesmic requirement	0.5g (Horizontal peak acceleration value).	0.5g (Horizontal peak acceleration value).	0.5g (Horizontal peak acceleration value).

However, for design purposes, ambient temperature should be considered as 50 degree centigrade and Relative humidity 100% for all three substations. Further altitude (from MSL) to be considered as 1190 Meter for Barhabise substation and less than 1000 Meter for Khimti Substation and 1420meter for Lapsiphedi.

5.0 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.

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.

6.0 BASIC REFERENCE DRAWINGS

6.1 The substations under present scope have the following Switching Schemes

Sl. No.	**Name of Substation**	**400kV Switching Scheme**	**220kV Switching Scheme**
1	400/220kV New Khimti S/S	One & half Breaker (GIS)	Double (DM) (GIS)
2	400/220kV Barhabise S/S	One & half Breaker (GIS)	Double (DM) (GIS)
3	400/220kV Lapsiphedi S/S	One & half Breaker (GIS)	Double (DM) (GIS)

6.2 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.

7.0 DIFFERENT SECTIONS OF TECHNICAL SPECIFICATION

7.1 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: Switchgear SA
Chapter 5: Auto Transformers
Chapter 6: Bus Reactor
Chapter 7: LT Switchgears
Chapter 8: EHV 220 kV XLPE Cable

Chapter 9: Lighting System
Chapter 10: Air Conditioning System
Chapter 11: Fire Protection System
Chapter 12: Power and Control Cable
Chapter 13: Battery & Battery Charger
Chapter 14: Switchyard Erection
Chapter 15: Structure
Chapter 16: Civil Works
Chapter 17: Control Relay and Protection Panels
Chapter 18: Substation Automation
Chapter 19: Fibre Optic Based Communication
Chapter 20: LT Transformers
Chapter 21: Drawings
Chapter 22: Technical Data Sheet (Guaranteed Technical Particulars)

7.2 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.

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

8.0 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.

9.0 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.

10.0 FACILITIES TO BE PROVIDED BY THE EMPLOYER

i. Owner shall make available the auxiliary HT power supply from NEA on chargeable basis at a single point in the Sub-station. The prevailing energy rates of the state shall be applicable. All further distribution from the same for construction and permanent auxiliary 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.

ii. The contractor shall make his own arrangement at his own cost for arranging water required for construction purpose. NEA/Consultant shall in no case be responsible for any delay in works because of non-availability or inadequate availability of water.

11.0 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 GIS, Transformers, EHV Cables, 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 BPS.

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	33kV	25kA , 3 sec
5	11 kV	25kA , 3 sec

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

6.1 Training at Manufacturer's works. The Contractor shall include in the training charges payment of per Diem allowance to NEA trainees @ **USD 150 per day per trainee** for the duration of training abroad towards accommodation, meals and other incidental expenses and to and fro economy class air ticket from Nepal to place of training. The duration of training shall be excluding travelling period.

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: 5 Days (4Nos. Trainees)

2. GIS Equipments and System:5 Days (4Nos Trainees)

3. EHV GIS Substation Design: 5 Days (4Nos. Trainees)

6.2 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. GIS Operation and Maintenance: 5 days.

4. Operation and Maintenance of Transformer & Reactors: 5 Days

7) 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.

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

9) *Under present scope of specification, one set of new 400kV Double Dead End(DDE) transmission tower each for New Khimti & Lapsiphedi substation is required for the termination of existing double circuit incoming line at the substation which shall be designed, supplied & erected(including foundation works) by the contractor. The tower shall be designed using reliability level 2.0. Payment for supply & Erection of 400kV DDE transmission tower shall be made on weight in metric ton basis under respective item of BPS. Regarding payment of tower foundation work, the quantity of excavation, concrete, reinforcement steel etc. shall be measured separately under respective items*

of BPS and paid accordingly.

Similarly, Supply & Installation of Insulator String (including Hardware fittings) at new Dead End tower & Takeoff gantry as well as supply & stringing of Conductor required for 400kV Incoming line termination is under the present scope of specification and the price for the same is deemed to be included on "Erection Hardware" item of BPS of respective substation. This price also includes all cost incurred for removing conductors, insulators, hardware (if any) during erection of new DDE tower. The position of the new tower will be finalized during detail engineering.

10) 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.

11) One number each Energy meter for the record and revenue purpose is to be provided for each 400/220 bays (transfer & Bus coupler bays to be excluded) under present scope of contract, meeting the requirement as specified at **Annexure – III.**

12) Non CFC refrigerant shall be utilized for Air conditioning system, offered for GIS Hall is under the scope of contract.

13) 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.

14) 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.

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

16) 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.

17) 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.

18) 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.

19) 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.

20) 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.

21) 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.

22) The switchyard panel room as detailed in section Sub-station Automation System is not required for GIS station. The contractor shall place their panels i.e. Bay level units, relay and protection panels, Digital RTCC panels, DPC panels etc for 400kV GIS hall or in a separate room in the 400 kV GIS buildings which shall be decided during detail engineering. The room shall be air-conditioned and the supplier shall submit detailed heat load calculation during detailed engineering. Further, the temperature of enclosure /room shall be monitored through substation automation system by providing necessary temperature transducers.

23) The Employer intends to carry out Type Test on 400 kV GIS and Dynamic Short Circuit Test (as Type Test) on all ratings of Power/Auto Transformers i.e. on one unit 53.33 MVA, 1-phase, 400/220kV Autotransformers & one unit 105 MVA, 1-phase, 400/220kV Autotransformers which shall be payable as per provisions of contract.

The price of conducting the test shall be quoted in the relevant schedule of Bid proposal sheet (BPS). The type test charges would be considered for evaluation. In case bidder does not quote any charges, it shall be carried out at no extra cost to Employer. Further, in case bidder indicates that he shall not carry out the test, his offer shall be considered incomplete and shall be liable to be rejected.
The Employer reserves the right to witness the type test. The contractor shall submit schedule at least 30 days in advance for conducting type test on the above items under the contract.

24) The duct connections should be such that it is possible to remove transformer for repair and maintenance conveniently

25) The price of Bus-duct inside the GIS hall shall be integral part of the respective bay module and it will not be paid separately. However, the payment of bus-duct

for outside the GIS hall along with support structure shall be paid as per running meters in line with provision of Bid Price schedule. Therefore, bidder is required to quote for 400kV and 220kV GIB (SF6 Gas insulated Bus Duct) of Line/Transformer/Reactor feeder module required outside GIS hall with support structure and SF6/Air bushing for interconnecting with its respective gantry / equipment (Overhead connection) separately as per provision of Bid price schedule.

26) The connection of 220 kV side of 400/220 kV Transformer with existing 220 kV GIS lines bays(to be used as 220 kV ICT bays) in all three substations will be made using 220 kV Gas Insulated Bus duct or 220 kV Cable or combination of both which shall be decided as per site condition during detail engineering.

27) Technical parameter for 72.5 kV Equipment's & 33 kV NCT is attached at **Annexure-V**

28) The reference of IS standard (i.e. Indian Standard) mentioned in the technical specification shall be read as equivalent IEC or BS or equivalent International Standard.

12.0 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

Mandatory Spares

S.N.	Item Description	Unit	Quantity		
			New Khimti	Barhabise	Lapsiphedi
A	**Spare for 400kV GIS**				
1.0	**General**				
1.1	SF6 gas Pressure Relief Devices, 3 Nos. of each type	Set	2	2	2
1.2	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
1.3	Coupling device for pressure gauge cum switch for connecting Gas handling plant	Set	2	2	2
1.4	Rubber Gaskets, “O” Rings and Seals for SF6 gas of each type	Set	1	1	1
1.5	Molecular filter for SF6 gas with filter bags	Set	20% of total weight	20% of total weight	20% of total weight
1.6	All types of Control Valves for SF6 gas of each type	Set	2	2	2
1.7	SF6 gas	LS	20 % of total gas	20 % of total gas	20 % of total gas
1.8	All types of coupling for SF6 gas (1 no. of each type)	Set	1	1	1
1.9	Pipe length (Copper or Steel as applicable) for SF6 Circuit of each type	Set	1	1	1
1.10	Density Monitors for SF6 Gas	No	1	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	2
1.11.2	For 1 phase enclosure if applicable	No	3	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
1.13	Bus support Insulator of each type for single phase/3 phase enclosure	No	5% of population	5% of population	5% of population

S.N.	Item Description	Unit	Quantity		
			New Khimti	Barhabise	Lapsiphedi
1.14	SF6 to air bushing (400KV) of each type & rating	Set	1	1	1
1.15	Spares for Local control cabinet including MCB, fuses, timers, Aux Relay of each type & rating terminal of each type	Set	1	1	1
2.0	**Circuit Breaker**				
2.0.A	**For 400 kV Circuit Breaker**				
2.1	Complete Circuit Breaker pole of each type & rating complete with interrupter, main circuit, enclosure and Marshalling Box with operating mechanism	Set	3	3	3
2.2	Fixed, moving and arcing contacts including insulating nozzles 3 Nos. of each type	Set	1	1	1
2.3	Rubber gaskets, `O' rings and seals for SF6 gas of each type	Set	1	1	1
2.4	Trip coil assembly with resistor as applicable, 3 Nos. of each type	Set	2	2	2
2.5	Closing coil assembly with resistor as applicable, 3 Nos. of each type	Set	2	2	2
2.6	Molecular filter for SF6 gas with filter bags	LS	10% of quantity	10% of quantity	10% of quantity
2.7	SF6 Pressure gauge cum switch or Density monitors and pressure switch as applicable, 3 nos each type	Set	1	1	1
2.8	Coupling device for pressure gauge cum switch for connecting Gas handling plant, 3 Nos. of each type	Set	1	1	1
2.9	Relays, Power contactors, push buttons, timers & MCBs etc of each type & rating	Set	1	1	1
2.10	Closing assembly/ valve, 3 Nos. of each type 1 No.	Set	2	2	2
2.11	Trip assembly/ valve, 3 Nos. of each type 1 No.	Set	2	2	2
2.12	Aux. switch assembly, 3 Nos. of each type	Set	1	1	1
2.13	Operation Counter, 3 Nos. of each type	Set	1	1	1
2.14	Rupture disc, 3 Nos. of each type	Set	1	1	1
2.15	Windoscope/Observing window, 3 Nos. of each type	Set	1	1	1

S.N.	Item Description	Unit	Quantity		
			New Khimti	Barhabise	Lapsiphedi
2.16	Spring operated closing mechanism, 1 No of each type, if applicable	Set	1	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	1
2.17.2	Ferrules, joints and couplings, 3 Nos. of each type	Set	1	1	1
2.17.3	Hydraulic filter, 3 Nos. of each type	Set	1	1	1
2.17.4	Hose pipe, 3 Nos. of each type	Set	1	1	1
2.17.5	N2 Accumulator, 3 Nos. of each type	Set	1	1	1
2.17.6	Pressure transducer, 3 Nos. of each type	Set	1	1	1
2.17.7	Valves 3 Nos. of each type	Set	1	1	1
2.17.8	Pipe length (copper & steel) 3 Nos. of each size & type	Set	1	1	1
2.17.9	Pressure switches 3 Nos. of each type	Set	1	1	1
2.17.10	Pressure gauge with coupling device, 3 Nos. of each type	Set	1	1	1
2.17.11	Hydraulic oil -20% of total requirement	Set	1	1	1
2.17.12	Pressure Relief Device, 3 Nos. of each type	Set	2	2	2
3.0	**ISOLATORS**				
3.0.A	**400 kV ISOLATORS**				
3.1	Complete set of 3 nos. of single phase / one no. of 3-phase dis-connector including main circuit, enclosure, driving mechanism	Set	1	1	1
3.2	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	1
3.3	3 no. of single phase / one no of 3-phase Earthing switch including main circuit, enclosure, driving mechanism	Set	1	1	1
3.4	Copper contact fingers for dis-connector male & female contact –for one complete (3 phase) dis-connector of each type and rating	Set	1	1	1
3.5	Copper contact fingers for earthing		1	1	1

S.N.	Item Description	Unit	Quantity		
			New Khimti	Barhabise	Lapsiphedi
	switch male & female contacts- for one complete (3 phase) earthing switch of each type and rating	Set			
3.6	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	1
3.7	Push button switch.-each type, as applicable	Set	1	1	1
3.8	**Limit switches and Aux. Switches for complete 3 phase equipment**				
3.8.1	For isolator	Set	3	3	3
3.8.2	For earth switch	Set	1	1	1
3.9	**Rotor housing bearing assembly for complete 3 phase equipment**				
3.9.1	For isolator	Set	2	2	2
3.9.2	For earth switch	Set	1	1	1
3.10	**Motor with gear assembly for complete 3 phase equipment**				
3.10.1	For isolator	Set	3	3	3
3.10.2	For earth switch	Set	1	1	1
3.11	Corona shield rings as applicable	Set	1	1	1
3.12	**Hinge pins for complete 3 phase equipment**				
3.12.1	For isolator	Set	3	3	3
3.12.2	For earth switch	Set	1	1	1
3.13	**Bearings for complete 3 phase equipment**				
3.13.1	For isolator	Set	5	5	5
3.13.2	For earth switch	Set	1	1	1
3.14	Interlocking coil with resistors, timers, key interlock for complete 3 phase equipment (each type and rating)	Set	1	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
3.15.2	For earth switch	Set	1	1	1
3.16	Aux. switch assembly (complete) with 10 NO & 10 NC or more contacts for both	Set	1	1	1

S.N.	Item Description	Unit	Quantity		
			New Khimti	Barhabise	Lapsiphedi
	isolator & earth switch				
4.0A	**400 KV CURRENT TRANSFORMER**				
4.1	Gas Insulated Complete CT of each type and rating with enclosure.	No	2	2	2
4.2	Secondary bushing of each type	Set	2	2	2
5.0A	**400kV VOLTAGE TRANSFORMER**				
5.1	Gas Insulated Complete PT of each type and rating with enclosure	No	2	2	2
6.0A	**Spares for Other Equipments :**				
1.0	**336 kV Surge Arrester (AIS) with insulating base, terminal connector , Surge counter & accessories**	No	1	1	1
2.0	**216 kV Surge Arrester (AIS) with insulating base, terminal connector , Surge counter & accessories**	No	1	1	1
7.0	**Relay and Protection Panel :**				
7.A	**Breaker Relay Panel**				
1	Breaker failure Relay	No	1	1	1
2	Trip/Close Circuit Supervision Relay	No	2	2	2
3	Self reset trip relay of each type (if applicable)	No	1	1	1
4	Auto Reclose relay with check synchronizing relay and dead line charging relay	No	1	1	1
5	Timer relay of each type (if applicable)	No	1	1	1
6	DC Supervision relays (if applicable)	No	1	1	1
7	Hand reset Trip Relay of each type (if applicable)	No	1	1	1
8	Flag relays of each type (if applicable)	No	1	1	1
9	Auxiliary relays of each type	No	1	1	1
7.B	**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	1
2	Main-2 Numerical distance relay (excluding external trip relays) with software and cable for front panel	Set	1	1	1

S.N.	**Item Description**	**Unit**	**Quantity**		
			New Khimti	**Barhabise**	**Lapsiphedi**
	communication to PC				
3	Disturbance recorder comprising of evaluation & acquisition units with software (if stand alone)	Set	1	1	1
4	Distance to fault locator including mutual compensation units (if stand alone)	Set	1	1	1
5	Over voltage protection relays with timers (Stage-I & Stage-II) (If stand alone)	Set	1	1	1
7.C	**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	1
2	Restricted Earth Fault protection relay with non linear resistor (if applicable) and associated software in case of numerical relay	No	1	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	1
4	Over fluxing relay (if stand alone)	Set	1	1	1
5	VT fuse failure relay (if applicable)	Set	1	1	1
6	Over load relay with timer (if applicable)	Set	1	1	1
7.D	**Reactor Protection Panel**				
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	-
2	Restricted Earth Fault protection relay with non linear resistor (if applicable) and associated software in case of numerical relay	No	-	1	-
3	Back up protection relay with 3 O/C and E/F element and associated software in case of numerical relay	Set	-	1	-
4	Over fluxing relay (if stand alone)	Set	-	1	-
5	VT fuse failure relay (if applicable)	Set	-	1	-
6	Over load relay with timer (if applicable)	Set	-	1	-
7.E	**Common Spares**				

S.N.	Item Description	Unit	Quantity		
			New Khimti	Barhabise	Lapsiphedi
1	Power supply module for Bus Bar Protection	Set	1	1	1
2	Metrosil (Non Linear resistor) each type if applicable	Set	1	1	1
3	Inter-posing CTs & PTs each type	Set	1	1	1
4	Power Supply module of Event logger	No	1	1	1
5	Processor Card of Event logger	Set	1	1	1
8.0	**Substation Automation system**				
1	Bay control unit with associated software	No	1	1	1
2	Ethernet switch of each type	No	1	1	1
3	Longest optical cable with end terminations	Set	1	1	1
9.0	**Fire Fighting System**				
9.1	**General**				
9.1.1	Quartzoid bulb detector	No	10% of total population	10% of total population	10% of total population
9.1.2	Projectors(Nozzles)	No	10% of total population	10% of total population	10% of total population
9.1.3	Smoke detectors				
9.1.3.1	Photo electric type	No	10% of total population	10% of total population	10% of total population
9.1.3.2	Ionisation type	No	10% of total population	10% of total population	10% of total population
9.1.4	Heat Detectors (for battery room)	No	10% of total population	10% of total population	10% of total population
9.1.5	Electrical Control Panel:Annunciation printed circuits (solid state annunciations) in Control Panel	Set	1	1	1
9.1.6	Strainer	Set	1	1	1
9.1.7	Deluge valve	No	1	1	1
9.1.8	Fire detection bulbs	No	10	10	10
9.1.9	Branch pipe fitted with nozzle & guide coupling	No	2	2	2
9.1.10	Hydrant Valve	No	1	1	1
9.1.11	Pressure switch	No	1	1	1

S.N.	Item Description	Unit	Quantity		
			New Khimti	Barhabise	Lapsiphedi
10.0	**420 kV ,50MVAR Bus Reactor**				
10.1	420 kV, 800 Amps, specified type bushing with metal parts and gaskets	No.	-	1	-
10.2	36 kV, 630 Amps bushing with metal parts and gaskets	No.	-	1	-
10.3	Local and remote WTI complete unit with sensing devices and contacts	Set	-	1	-
10.4	Local and Remote OTI complete unit with contacts and sensing bulbs	Set	-	1	-
10.5	Magnetic Oil Level gauge	No.	-	1	-
10.6	Pressure Relief Device	Nos.	-	2	-
10.7	Buchholz relay complete with float and contacts	No.	-	1	-
10.8	Flexible air cell		-	1	-
10.9	Neutral Current Transformer	Sets	-	2	-
10.10	Breather assembly	Sets	-	2	-
10.11	MCBs/MCCBs of each type used	No.	-	1	-
10.12	Sets of fuses of each type used	Sets	-	3	-
10.13	Oil pumps with motor & starter	Set	-	1	-
10.14	Fan Contactors used in the cooler control circuit of each type used	Nos.	-	2	-
10.15	Relays used in the cooler control circuit of each type used	Nos.	-	2	-
10.16	Indication lamps (one of each type)	Nos.	-	5	-
11.0	**Batteries and Battery Charger**				
11.1	**220V Battery Chargers**				
11.1.1	Set of Control Cards	Set	1	1	1
11.1.2	Set of relays	Set	1	1	1
11.1.3	Rectifier transformer	No.	1	1	1
11.1.4	Thyristor/ Diode	Set	1	1	1
11.1.5	Fuses of Thyristor with indicators	Set	6	6	6
11.2	**48V Battery Chargers**				
11.2.1	Set of Control Cards	Set	1	1	1

S.N.	Item Description	Unit	Quantity		
			New Khimti	Barhabise	Lapsiphedi
11.2.2	Set of relays	Set	1	1	1
11.2.3	Rectifier transformer	No.	1	1	1
11.2.4	Thyristor/ Diode	Set	1	1	1
11.2.5	Fuses of Thyristor with indicators	Set	6	6	6
12.0	**LT Switch Gear**				
12.1	Relays	Set	1	1	1
12.2	CTs and PTs	Set	1	1	1
12.3	Switches/ Push buttons and Meters	Set	1	1	1
12.4.A	TPN Switches / MCB	Set	1	1	1
12.4B	MCCB of each rating	Set	1	1	1
12.5	LT Breaker Spares :				
12.5.1	Spring Charging motor	No	1	1	1
12.5.2	Aux. Contact sets	Set	2	2	2
12.5.3	Bus Bar seal off insulators	No	5	5	5
12.5.4	Arc Chutes	Set	2	2	2
12.5.5	Moving contacts	Set	1	1	1
12.5.6	Arcing contacts (Fixed/Moving)	Set	1	1	1
12.5.7	Springs(Closing/Opening)	No	1	1	1
12.5.8	Closing Coil	No	1	1	1
12.5.9	Tripping Coil	No	1	1	1
12.5.10	Aux. finger contact	Set	1	1	1
12.5.11	Limit Switches	Set	1	1	1
12.5.12	Jaw Contacts	Set	1	1	1
12.5.13	Bus Bar Insulators	No	5	5	5
12.5.14	Interphase Barrier	No	2	2	2
12.5.15	Bus Bar Stip1 mm (Aluminium)	MTR	5	5	5
13.0	**Illuminations**	LS	5% of each type of lighting fixture supplied	5% of each type of lighting fixture supplied	5% of each type of lighting fixture supplied
14.0	**Erection Hardware :**				
14.1	5% spares of the actual quantities for Insulator strings & hardwares, clamps & connectors (including equipment	LS	1	1	1

S.N.	Item Description	Unit	Quantity		
			New Khimti	Barhabise	Lapsiphedi
	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)				
15.0	**400/220 kV Auto Transformers :**				
15.1	HV (420 kV), specified type bushings with with gaskets etc.	No.	1	1	1
15.2	245kV, specified type bushings with gaskets etc.	No.	1	1	1
15.3	LV (52kV) bushings complete with gaskets etc.	No.	1	1	1
15.4	HVN(52kV) neutral bushing complete with gaskets etc.	No.	1	1	1
15.5	Gaskets for all openings on Transformer tank.	Set	1	1	1
15.6	Oil and Winding Temperature Indicators.	Nos.	6	6	6
15.7	Magnetic oil level gauge.	No.	1	1	1
15.8	Pressure Relief Device.	No.	1	1	1
15.9	Oil pumps with motor & starter.	No.	1	1	1
15.10	Oil flow indicator.	Nos.	2	2	2
15.11	Contactors used in the cooler control circuit.	Nos.	6	6	6
15.12	Relays used in the cooler control circuit.	Nos.	6	6	6
15.13	Indication lamps assembly complete used in the Marshalling box/marshalling box.	Nos.	10	10	10
15.14	MCCBs/ MCBs used in Marshalling Box/RTCC/Panels	Nos.	6	6	6
15.15	Buchhloz Relay	Nos.	2	2	2
15.16	Valves of each type used	Nos.	2	2	2
15.17	Air cell	Nos.	1	1	1
15.18	Neutral CTs	Nos.	1	1	1
15.19	Switches/ Push Buttons used in the	No	9	9	9

S.N.	Item Description	Unit	Quantity		
			New Khimti	Barhabise	Lapsiphedi
	panels	s.			
15.20	Heater used in the panels	Nos.	2	2	2
15.21	Thermostat used in the panels	Nos.	2	2	2
15.22	Terminal blocks used in the panels	Nos.	6	6	6
15.23	Relay for OLTC	Nos.	1	1	1
15.24	Drive Motor for OLTC with gear assembly	Nos.	1	1	1
15.25	Fuses used in panels	Nos.	9	9	9
15.26	Breather for Conservator tank	Nos.	3	3	3
15.27	Silicagel	kg	6	6	6
15.28	Oil Sampling bottle of stainless steel having capacity of 1 litre	No.	1	1	1
15.29	Oil Syringe as per TS	Set	1	1	1
15.30	Hand Tools as per TS	Set	1	1	1
15.31	BDV Kit	Set	1	1	1
15.32	Portable DGA Kit	Set	1		

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 be able to communicate to the remote end interfacing with SDH terminal equipment at its 2Mbps port as well as using separate fibres. 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) Specific power supply tests

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)

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.

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 sub station premises covering the areas of entire switchyard, Control Room cum Administrative building, Fire fighting pump house, 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 765kV 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 Electro magnetic 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 765/400KV 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℃ ~ +50℃
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

ANNEXURE– V

Technical parameter for 72.5 kV Equipment's & 33 kV NCT

A. Technical Parameters for 72.5 kV Current Transformers

1	Rated Primary current	50 A
2	Rated extended current	120%
3	Rated short time current	25 kA for 3 sec.
4	Rated dynamic current	63 kAp
5	Maximum temperature rise over design ambient temperature	As per IEC-60044-1
6	One minute power frequency withstand voltage sec. terminal & earth	5 kV (rms)
7	Number of terminals	All terminals of control circuits are to be wired upto marshalling box plus 20% spare terminals evenly distributed on all TBs.
8	Type of insulation	Class A

Current transformers shall also comply with requirements of technical specification & below table.

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
2	1	O/C & E/F	50/1	10	5P10
	2	Metering	50/1	10	0.5

B. TECHNICAL PARAMETERS FOR 72.5 kV VOLTAGE TRANSFORMERS

1.	System Fault level	25kA for 3 second
2.	Standard reference range of frequencies for which the accuracies are valid	96% to 102% for protection and 99.5 to 101% for measurement
3.	One minute power frequency withstand voltage for secondary winding	3kV (rms)
4.	Maximum temperature rise over design ambient	As per IEC:60044-2 or IEC:60044-5

	temperature	
5	Number of terminals in control cabinet	All terminals of control circuits are wired upto marshalling box plus 20% spare terminals evenly distributed on all TBs.

Voltage Transformers shall also comply with requirements of technical specification & below table.

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	**3P**	0.5
9.	Output Burden (VA) (minimum)	10	10

C. Technical Parameters for 72.5 kV Circuit Breaker

1.	Rated continuous current (A) at design ambient temperature of 50oC	1250
2.	Rated short circuit current breaking capacity at rated voltage	25kA with percentage DC component as per IEC 62271-100 corresponding to minimum opening time under operating conditions specified.
3.	Symmetrical interrupting capability kA (rms)	25
4.	Rated short circuit making current kA (peak)	63
5.	Short time current carrying capability for three second kA (rms)	25
6.	Rated line/cable charging interrupting current at 90o leading power factor angle (A rms)	As per IEC

	(The breaker shall be able to interrupt the rated line charging current with test voltage immediately before opening equal to the product of U/_/3 and 1.4 as per IEC 62271-100	
7.	Maximum allowable switching over voltage under any switching condition	As per IEC
8.	Total break time as per Clause 3.0 of Technical specification. (ms)	Less than 80
9.	Rated break time as per IEC (ms)	Less than 75
10.	Total closing time (ms)	Not more than 200
11.	Rated operating duty	O-0.3S-CO-3min-CO Cycle
12.	Operating mechanism	Spring
13.	Trip coil and closing coil voltage	220V DC with variation as specified in clause 8.2.5 of Tech. spec.
14.	Auxiliary contacts	Besides requirement of Technical specification, the contractor shall wire up 2 NO + 2 NC contacts for future use of Employer
15.	Noise level at base and upto 50 m distance from base of breaker	140 dB (Max.)
16.	Rated terminal load	As per IEC or as per the value calculated in section - GTR of Tech. Spec., whichever is higher.
17.	Temperature rise over the design ambient temperature	As per IEC 60694
18.	First pole to clear factor	1.5
19.	No. of terminals in common control cabinet	All contacts & control circuits to be wired out upto common control cabinet plus 10 Terminals exclusively for Employer's use.

72.5 kV CB shall also comply with requirements of technical specification.

D. Technical Parameters for 72.5 kV Isolator

1.	Rated voltage	72.5 kV
2.	Rated current	400 A
3.	Standards	IEC 62271-102
4.	Rated short time withstand (in KA)	25KA for 3 sec.
5.	Operating drive	AC Motor operated (isol) Manual operated (E/S)
6.	Type	Double break Isolator without E/S, 3 pole, outdoor, Gang operated
7.	Interlock	Electrical interlock with circuit breaker. Mechanical castle key interlock to be provided between electrical and manual operation.
8.	Construction details	All ferrous parts to be galvanized

		except nuts and bolts which shall be electroplated as per relevant IS
9.	Terminal connector	To suit site conditions and layout requirements.
10	Operating time	12 seconds or less

72.5 kV Isolator shall also comply with requirements of technical specification.

E. Technical Parameters of 33 kV Neutral Current Transformers(NCT)

33 kV Neutral Current Transformer (NCT) shall also comply with the requirements of technical specification & below Table

Description	Current Transformer Parameters (Transformer)
CORE 1	**Ratio** 1000/1
CORE 1	**Minimum knee point voltage or burden and accuracy class** : 600V, TPS
CORE 1	**Maximum CT Secondary Resistance** : 1.5 Ohm
CORE 1	**Application** : Restricted Earth Fault
CORE 1	**Maximum magnetization current (at knee point voltage):** 100 mA

Note: *The CT ratio shall be finalized during detail engineering*

ANNEXURE- VI

LIST OF PREFERED (SHORTLISTED) MAKE

It is preferred that the following equipment be supplied from the manufacturers listed hereunder:

(i) M**ain Protection Relays, Control &Relay panel, Substation Automation System from:** ABB, AREVA / ALSTOM, SIEMENS, Fuji, Reyrolle, Toshiba, Mitsubishi, GE or equivalent.

(ii) **Energy Meters from:** ELSTER (ABB), ACTARIS (Schlumburger), EDMI, SIEMENS or equivalent.

(iii) **SF6 Circuit Breakers from:** ABB, AREVA /ALSTOM, Hitachi, Siemens, Toshiba/Mitsubishi, LG, Fuji, GE or equivalent.

(iv) **VCB Switchgear from:** ABB, AREVA/ALSTOM, Hitachi, Siemens, Toshiba/Mitsubishi, LG, Fuji, GE, Schnieder Electric or equivalent.

(v) **On-Load Tap Changer:** The on-load tap-changer (OLTC) to be equipped on the power transformers and associated control equipment shall be from MR Germany or ABB Sweden

(vii) ***Temperature Indicators*****:** shall be from AB Khilstrom, Sweden or equivalent

(vi) **Gas Insulated Substation:** ABB, AREVA/ALSTOM, SIEMENS, Toshiba / Mitsubishi, GE, HYOSUNG, Hyundai, Hitachi or equivalent.

(vii) **Communication System:** NOKIA, NOKIA SIEMENS, SIEMENS, ABB, AREVA/ALSTOM or equivalent

The bidders may offer equipment/brands other than those listed above that are better or equivalent with regard to quality and performance substantiated with appropriate documents. The bidder is required to submit all technical information, brochures, test reports of the proposed equipment for assessing equivalence with the shortlisted vendor during the bid submission.

TECHNICAL SPECIFICATIONS

TOWER, FOUNDATION, ERECTION, STRINGING

1.0 General

The scope of works comprises of design, manufacture, shop test, supply, erection, field testing and commissioning of self-standing, galvanized latticed double dead end type steel towers with suitable body/leg extension designed to carry the line conductors with necessary insulators, earth wires and all fittings under all loading conditions., two for each of the New Khimti and Lapsiphedi substation. The tower shall be designed using reliability level 2.0. The Contractor shall investigate the site and propose a suitable tower type and location.

In order to minimize the power interruption during the dismantling, re-erection and interconnecting works, the Contractor is required to develop the construction methodology, shut-down sequences and schedules etc., and obtain prior approval from NEA. The Contractor is also required to study the transmission system of Nepal and familiarize himself thoroughly the operation system of NEA before executing the mentioned work. The project office shall assist the Contractor obtaining the necessary information and permission

1.1 General Description of the Tower

1.1.1 The towers shall be self-supporting, hot dip galvanised, latticed steel type & designed to carry the line conductors with necessary insulators, earth wires and all fittings under all loading conditions.

1.2 Classification of Towers

1.2.1 The towers for 400 kV Lines are classified as given below:

Type of Tower	**Deviation Limit**	**Typical Use**
DA	0-2 deg	a) To be used as tangent/suspension tower with suspension insulator strings
DB	2 to 15 degrees	a) Angle towers with tension insulator string. b) Also to be used for uplift force resulting from an uplift span up to 600m under broken wire conditions c) Also to be used for Anti Cascading Condition.

DB	0 degree	To be used as Section Tower.
DC	15 to 30 degrees	a) Angle tower with tension insulator string. b) Also to be used for uplift forces resulting from an uplift span up to 720m under broken wire condition. c) Also to be used for anti-cascading condition.
DC	0 deg.	To be used as Section tower.
DD	30 - 60 deg.	a) Angle tower with tension insulator string. b) Also to be used for uplift forces resulting from an uplift span up to 900m under broken wire condition. c) Dead end with 0 deg to 15 deg deviation both on line side and sub-station side (slack span)
DDE	0 deg.	a) Complete dead end. b) For river crossing anchoring with longer wind span & 0 deg. deviation on crossing span side and 0 deg to 30 deg. deviation on other side.

1.2.2 Extensions

1.2.2.1 The Double Circuit towers shall be designed so as to be suitable for adding –3M, -1.5M, 1.5M, 3M, 4.5M, 6M, 7.5M and 9M body extensions / leg extensions *where necessary* for maintaining adequate ground clearances without reducing the factor of safety (actual stress /allowable stress)

1.3 Spans

1.3.1 Design Span or Normal Span

The Design Span or Normal Ruling Span of the line is **400m** for 400KV transmission line.

.1.3.2 Wind Span

The wind span is the sum of the two half spans adjacent to the tower under consideration. For normal horizontal spans this equals to normal ruling span.

1.3.3 Weight span

The weight span is the horizontal distance between the lowest point of the conductors on the two spans adjacent to the tower. For spotting of structures, the span limits are given in Table 1.3.1 below

TABLE 1.3.1 (400 kV)

TOWER TYPE	NORMAL CONDITION		BROKENWIRE CONDITION	
	MAX (m)	MIN (m)	MAX (m)	MIN (m)
DA	600	200	360	100
DB	1000	(-)1000	600	(-) 600
DC	1200	(-)1200	720	(-) 720
DD/DDS	1600	(-)1500	960	(-) 900

1.3.4 In case at certain locations where actual spotting spans exceed the design spans and cross-arms and certain members of towers are required to be modified/ reinforced, in that case design, structural & shop drawings for the modified/ reinforced towers will be prepared by the Contractor as per requirement on basis of approved line diagram without any additional financial implications to the Employer for the design and drawings.

1.4 Electrical Clearances

1.4.1 Ground Clearance (400kV)

The minimum ground clearance from the bottom conductor shall not be less than 9500 mm for 400kV lines at the maximum sag conditions i.e at 80°C and still air.

a) An allowance of 150mm shall be provided to account for errors in stringing.

b) Conductor creep shall be compensated by over tensioning the conductor at a temperature of 26°C, lower than the stringing temperature for ACSR “MOOSE” for 400kV transmission lines.

1.4.2 Power Line Crossing

Minimum clearance between power lines to power line crossing should be 5490 mm for 400kV.

1.4.4 Live Metal Clearance

The minimum live metal clearance to be provided between the live parts and steel work of superstructure shall be as given in Table 1.2

TABLE 1.2

(400kV)

DESCRIPTION	SWING ANGLE	LIVE METAL CLEARENCE
Suspension String (Single / Double)	NIL	3620 mm
	15 Degree	3620 mm
	25 Degree	3620 mm
	40 Degree	2210 mm
Tension String (Single / Double)	--	3620 mm
Jumper	NIL	3620 mm
	25 Degree	3620 mm
	40 Degree	2210 mm

NOTE: in case of pilot insulator strings, the angle of swing of the jumper alongwith the pilot string shall be considered as 15 deg.

1.4.5 Bidder shall adopt same cross arm design where jumper is projecting outside of cross-arm for DD type tower, used as dead end and angle tower.

1.4.6 The design of the tower shall be such that it should satisfy all the above conditions when clearances are measured from any live point of the strings. As the Contractor may use & supply insulator strings with disc insulators or long rod insulators or polymer insulators, the tower design shall be such that it satisfies the clearance requirements in that particular case.

1.4.7 Cross arm projections for Dead end towers shall be fixed in such a way that it can accommodate a condition of 0º to 90º deviation of conductors towards tower at both Left and Right side cross arms on slack span side(Substation Gantry side) and 0-15 degrees deviation on line side. I*f necessary, Auxiliary Crossarm shall also be provided to get required deviation angle.*

1.4.8 Angle of Shielding

The angle of shielding is defined as the angle formed by the line joining the centre lines of the earthwire and outer power conductor in still air at tower supports, to the vertical line through the centre line of the earthwire. Bidders shall design the tower in such a way that the angle of shielding does not exceed 20 deg for all towers for 400kV & 30 deg for all towers for 132 kV. The drop of the earthwire clamp equal to 150 mm should be considered while calculating the minimum angle of protection.

1.4.9 Mid Span Clearance

The minimum vertical mid span clearance between the earthwire and the nearest power conductor shall not be less than 9.0 metres (for 400kV) & 6.33 meters(for 132kV)), which shall mean the vertical clearance between earthwire and the nearest conductor under all temperatures and still air condition in the normal ruling span. Further, the tensions of the earthwire and power conductor, shall be so co-ordinated that the sag of earthwire shall be at least 10% less than that of power conductors under all temperature loading conditions.

1.5 Normal Loading Conditions

1.5.1 Loads at Conductor and Earthwire Points

-The Contractor shall develop the tower designs based on relevant design standards.The contractor has to apply wind loads as per the relevant design standards in addition to the point loads on the towers.

1.5.2 Wind Loads on Tower Body

The wind load on tower body shall be calculated by the Contractor as per clause 9.1 of IS 802(Part 1/Sec 1):1995. The following data shall be considered for calculating wind load on tower body.

a) Dynamic reference wind pressure shall be considered as 89.6 kg/m^2 for all 400 kV towers and multi-circuit towers of 132 kV whereas it shall be taken as 71.5 kg/m^2 for 132 kV DA and DD towers.

b) Reliability Level and Terrain category shall be considered as 2 for 400 kV and multi-circuit towers of 132 kV & Reliability Level 1 and Terrain category 2 shall be considered for 132 kV

c) The angle of incidence of Wind θ (Theta) = 0 Degree.

1.5.3 Maximum Tension

1.5.3.1 Max. tension for non-snow zone (DA/DB/DC/DD towers) shall be based on either

a) at 0 deg C with 36 percent full wind pressure, or

b) at 32 deg C with full wind pressure whichever is more stringent.

1.5.3.2 The initial conductor and earthwire tension (maximum) at 32ºC and without wind shall be 22% of the ultimate tensile strength of the conductor and 20% of the ultimate tensile strength of the earthwire.

1.5.4 Limiting Tensions of Conductor & Earthwire

The ultimate tension of conductor and earthwire shall not exceed 70 per cent of the ultimate tensile strengths.

1.5.5 Broken Wire Condition

1.5.5.1 Tower Type DB and DC

For 400 KV

Breakage of any two phases (all four sub-conductors) on the same side and on the same span or breakage of any one phase (all four sub-conductors) and one earthwire on the same side and same span whichever combination is stringent for a particular member.

For 132 kV

Breakage of any two phases on the same side and on the same span or breakage of any one phase and one earthwire on the same side and same span whichever combination is stringent for a particular member.

1.5.5.2 Tower Type DD/DDS

Breakage of all the three phases (all four sub-conductors) on the same side and on the same span or breakage of two phases (all four sub-conductors) and one earthwire on the same side and on the same span, whichever combination is more stringent for a particular member.

1.5.5.3 Tower Type DA or QA

Breakage of any one phase (all four sub-conductors for 400 kV)) or one earthwire whichever is stringent for a particular member. 75% wind loading on tower shall be taken in broken wire condition for DA/QA type tower.

1.6 Design of Towers

1.6.1 Design Criteria

Towers shall be designed based on spans and clearances as per Clause 1.3 & 1.4 and loading conditions as per Clause 1.5 above.

1.6.2 Design Temperatures

The following temperature range for the conductors and ground wires shall be adopted for line design:

i)	Minimum Temperature	:	-5 deg.C
ii)	Every day temperature of conductor	:	32 deg.C
iii)	Max. temperature of		

a) Conductor	:	80 deg.C
b) Earthwire exposed to sun	:	53 deg.C

1.6.3 Conductor and Earthwire Configuration

For double circuit towers the three phases shall be in vertical formation. The phase to phase spacing for conductors shall be not less than 8.0 meters (400 KV) and 4.05 meters (132 KV) vertically. However, the minimum horizontal separation between phase conductors of two circuits shall be 9.0 meters (400 KV) and 6.33 meters for 132 KV.

1.6.4 Redundant Design

1.6.4.1 All redundant in the tower are to be triangulated.

1.6.4.2 All bracing and redundant members of the towers which are horizontal or inclined up to 15º from horizontal shall be designed to withstand an ultimate vertical load of 1500 N considered acting at centre independent of all other loads. The bending moment for designing of redundant members shall be considered as WL/4 irrespective of end connections and continuity. The contractor has to furnish the calculations for the same (where W is ultimate load of 1.5 kN and 'L' is the length of redundant from bolt to bolt).

1.6.4.3 All redundant shall be designed individually for 2.5% of maximum axial load of connecting members (i.e. leg members, bracing members etc.). The contractor has to furnish the calculations for the same.

1.6.4.4 Connection of single Redundant to leg member having a section of 110 x 110 x 10 and above shall be done with minimum of 2 bolts.

1.6.5 THICKNESS OF MEMBERS

The minimum thickness of angle sections used in the design of towers, unless otherwise specified elsewhere in this Specification, shall be kept not less than the following values:

a) Main corner leg members including the earthwire peak and main cross arm	:	5 mm
b) For all other members	:	4 mm

1.6.6 **BOLTS AND NUTS**

1.6.6.1 The minimum bolt spacing and rolled edge distance and sheared edge distance from the centers of bolt holes to be maintained are given in Table 1.3

TABLE 1.3

Diameter of Bolt (mm)	Hole Diameter (mm)	Min. Bolt Spacing (mm)	Min. Rolled Distance (mm)	Min. Sheared Edge Distance (mm)
16	17.5	40	20	23
24	25.5	60	33	38

Bolts sizes mentioned above shall only be used. The minimum width of the flanges without bolt holes shall be 30 mm

1.6.6.2 For the purpose of calculating shearing stress and bearing stress for bolts clause 5.4 of IS: 802 (Part-1/Sec 2):1992 shall be referred.

1.6.7 SLENDERNESS RATIO

1.6.7.1 Slenderness ratio for members shall be computed in accordance with clause 6.4 of IS: 802 (Part-1/Sec 2):1992. Slenderness ratio for compression and tension members shall not exceed the values specified therein**.**

1.6.7.2 The following maximum limit of the slenderness ratio i.e. the ratio of unsupported length of the section in any plane to the appropriate radius of gyration will be adopted:

		VALUE OF KL/R
a)	For main corner leg members including the corner members of earthwire peak and the lower corner members of the cross-arms	120
b)	For other members having calculated stresses	200
c)	For redundant members	250
d)	For members having tensile stress only	375

1.6.8 ERECTION STRESS

Where erection stress combined with other permissible co-existent stresses could produce a working stress in any members appreciably above the specified working stress, such other provision are to be made as may be necessary to bring the working stress within the specified limit**.**

1.6.9 STRUCTURAL ARRANGEMENT OF MEMBERS IN A TOWER

1.6.9. Lifting Points shall be provided in the tension tower and shall be designed for a load of 1020 kg assumed as acting at a 600 mm distance from the tip of the cross arm.

1.6.9.2 Internal angle between two members shall not be less than 15 degrees.

1.6.10 Design Calculation and Drawings

1.6.10.1 The following design calculation and drawings are required to be furnished to the Employer:

A) After award of contract:

The Contractor shall submit detailed design of tower & extension alongwith stress diagram / computer output together with sample calculations for few critical members etc., stub templates and loading / rigging arrangement of tower testing to enable the Employer to make a preliminary check regarding structural stability of tower (before) tests.

1.6.10.2 After subsequent approval of design, drawings and bill of materials, the Contractor shall furnish the following in ten (10) copies to the Employer for necessary distribution with in fifteen(15) days after approval of drawings:

a) Detailed design calculation and drawing for towers and foundations.

b) Detailed structural drawings indicating section size, length of members, sizes of plates along with hole to hole distance & joint details etc.

c) Bill of materials, indicating cutting and bending details against each member.

d) Shop drawings showing all details relevant to fabrication.

e) All the drawings for the tower accessories.

1.6.10.3 The Contractor is required to submit four copies of the drawings as mentioned in clause 1.6.10.2 for Employer's approval. While submitting the designs, structural drawings bill of materials and any other drawing pertaining to the subject transmission line, the Contractor shall clearly indicate on each drawing NEA Specification No., Name of the transmission line and project , letter reference No. and date on which the submission are made. The same practice is also to be followed while submitting distribution copies.

1.6.10.4 The design and drawings as covered in clause 1.6.10.1 (~~B~~A) above shall be approved / commented by the Employer as the case may be within twenty eight (28) days of receipt of design / drawings in NEA office. If the design / drawings are commented by the Employer, the Contractor shall submit revised designs / drawings with in fifteen (15) days of date of issue of comments.

1.6.10.5 The Contractor is required to furnish the progress of submissions and approvals of designs and drawings on twenty fifth day of every month till the completion of all the design activities.

The details shall include description of design / drawing, schedule date of submission, actual date of submission schedule date of approval ,actual date of approval, schedule date of submission of distribution copies, actual date of submission of distribution copies, schedule date of tower test, actual date of tower test and 'Remarks' column. Provision of six additional columns shall also be made in the above progress report to indicate date of comments issued by the Employer and details of submission of revised designs / drawings.

1.6.10.6 The tower accessories drawings like name plate, danger plate, phase plate, circuit plate, anticlimbing device, step bolt, D-shackle etc. shall also be prepared by the Contractor and shall be submitted to the Employer, in three copies, along with one reproducible, for record. These drawings shall be prepared in A4 size only.

1.6.10.7 All the drawings shall have a proper name plate clearly displaying the name of Employer on right hand bottom corner. The approval for exact format of the nameplate shall be obtained by the successful bidder from the Employer for adopting the same on all the drawings. Also all the drawings shall carry the following statement and shall be displayed conspicuously on the drawing:

WARNING: THIS IS PROPRIETORY ITEM AND DESIGN RIGHT IS STRICTLY RESERVED WITH NEPAL ELECTRICITY AUTHORITY (NEA). UNDER NO CIRCUMSTANCES THIS DRAWING SHALL BE USED BY ANYBODY WITHOUT PRIOR PERMISSION FROM NEA IN WRITING.

1.7 Materials

1.7.1 Tower Steel Sections

1.7.1.1 IS Steel Sections of tested quality of conformity with IS:2062:2011 grade E250 (Designated Yield Strength. 250 MPa) and/ or grade E350 (Designated Yield Strength 350 MPa) are to be used in towers, extensions, stubs and stub setting templates. For Snow Zone towers MS & HT Steel Sections shall conform to E250 Grade-C & E350 Grade-C respectively. The Contractor can use other equivalent grade of structural steel angle sections and plates conforming to latest International Standards viz BSEN 10025. However, use of steel grade having designated yield strength more than that of EN 10025 grade S355 JR/JO (designated yield strength 355 MPa) is not permitted, unless otherwise indicated in this specification.

1.7.1.2 Steel plates below 6mm size exclusively used for packing plates/packing washers produced as per IS : 1079 (Grade-0) are also acceptable. However, if below 6mm size plate are used as load bearing plates viz gusset plates , joint splices etc. the same shall conform to IS : 2062 or equivalent standard meeting mechanical strength/metallurgical properties corresponding to grade E250 or above grade (designated yield strength not more than 355MPa), depending upon the type of grade incorporated into design. Flats of equivalent grade meeting mechanical strength/ metallurgical properties may also be used in place of plates for packing plates/ packing washers. The chequered plates shall conform to IS : 3502. SAILMA 350HI grade plate can also be accepted in place of HT plates (EN 10025 grade S355 JR/JO / IS 2062:2011 – grade E350, as applicable) provided SAILMA 350HI grade plate meet all the mechanical properties of plate as per EN 10025 grade S355 JR/JO (designated yield strength 355 MPa) / IS 2062: 2011 – grade E350.

1.7.1.3 For designing of towers, preferably rationalised steel sections shall be used. During execution of the project, if any particular section is not available, the same shall be substituted by higher section at no extra cost to Employer and the same shall be borne by the Contractor. However, design approval for such substitution shall be obtained from the Employer before any substitution.

1.7.2 Fasteners: Bolts, Nuts and Washers

1.7.2.1 All tower members shall be joined together with Bolts and nuts. All hexagonal bolts and nuts shall conform to IS-12427. They shall have hexagonal head and nuts, the heads being forged out of the solid, truly concentric, and square with the shank, which must be perfectly straight.

All bolts and nuts shall be galvanised as per IS:1367 (Part-13) / IS:2629 .

1.7.2.2 The bolt shall be of 16 / 24 mm diameter and of property class 5.6 as specified in IS:1367 (Part-III) and matching nut of property class 5.0 as specified in IS:1367 (Part-VI).

1.7.2.3 Bolts up to M16 and having length up to 10 times the diameter of the bolt should be manufactured by cold forging and thread rolling process to obtain good and reliable mechanical properties and effective dimensional control. The shear strength of bolts for 5.6 grade should be 310 MPa minimum as per IS:12427. Bolts should be provided with washer face in accordance with IS: 1363 (Part-I) to ensure proper bearing.

1.7.2.4 Nuts for hexagonal bolts should be double chamfered as per the requirement of IS: 1363 Part-III. It should be ensured by the manufacturer that nuts should not be over tapped beyond 0.4mm oversize on effective diameter for size up to M16.

1.7.2.5 Fully threaded bolts shall not be used. The length of bolts shall be such that the threaded portion will not extend into the place of contact of the members.

1.7.2.6 All bolts shall be threaded to take the full depth of the nuts and threaded for enough to permit firm gripping of the members, but not further. It shall be ensured that the threaded portion of each bolt protrudes not less than 3mm and not more than 8mm when fully tightened. All nuts shall fit tight to the point where the shank of the bolt connects to the head.

1.7.2.7 Flat and tapered washers shall be provided wherever necessary. Spring washers shall be provided for insertion under all nuts. These washers shall be steel electro-galvanised, positive lock type and 3.5mm in thickness for 16mm diameter bolt and 4.5 mm for 24 mm bolt.

1.7.2.8 To avoid bending stress in bolts or to reduce it to minimum, no bolt shall connect aggregate thickness of members more than three (3) times its diameter.

1.7.2.9 The bolt positions in assembled towers shall be as per IS: 5613 (Part-II / Section 2) -1976.

1.7.2.10 Bolts at the joints shall be so staggered that nuts shall be tightened with spanners without fouling.

1.7.2.11 To ensure effective in-process Quality control it is desirable that the manufacturer should have in house testing facility for all tests like weight of zinc coating, shear strength and other tests etc. The manufacturer should also have proper Quality Assurance System which should be in line with the requirement of this specification and IS: 14000 series Quality System Standard.

1.8 Tower Accessories

Arrangement shall be provided for fixing of all tower accessories to the tower at a height between 2.5 meters and 3.5 meters above the ground level.

1.8.1 Step Bolts & Ladders

Each tower shall be provided with step bolts conforming to IS: 10238 of not less than 16mm diameter and 175 mm long spaced not more than 450mm apart and extending from 2.5 meters above the ground level to the top of the tower. However, the head diameter shall be 50mm as indicated in the enclosed drawing. For double circuit tower the step bolt shall be fixed on two diagonally opposite legs up to top of the towers. Each step bolt shall be provided with two nuts on one end to fasten the bolt securely to the tower and button head at the other end to prevent the feet from slipping away. The step bolts shall be capable of withstanding a vertical load not less than 1.5 KN. For special towers, where the height of the super structure exceeds 50 meters, ladders along with protection rings as per the Employer's approved design shall be provided in continuation of the step bolts on one face of the tower from 30 meters above ground level to the top of the special structure. From 2.5m to 30m height of super structure step bolts shall be provided. Suitable platform using 6mm thick perforated chequered plates along with suitable railing for access from step bolts to the ladder and from the ladder to each cross-arm tip and the ground wire support shall also to be provided. The platform shall be fixed on tower by using counter-sunk bolts.

1.8.2 Insulator String Attachments

Strain plates of suitable dimensions under each cross-arm tip, shall be provided for taking the hooks or D-shackles of the tension insulator strings. Full details of the attachments shall be provided by the contractor. To achieve requisite clearances, if the design calls for providing extra D-shackles, link plate etc. before connecting the insulator string the same shall be supplied by the Contractor.

1.8.3 Earth wire Clamp Attachments

Earth wire peaks of tension towers shall be provided with suitable plates to accommodate the shackle of tension clamps. The contractor shall also supply the U-bolts wherever required and take Employer's approval for details of the attachments before the mass fabrication.

1.8.4 Anti Climbing Device

Barbed wire type anti climbing device, as per enclosed drawing shall be provided and installed by the Contractor for all towers. The barbed wire shall conform to IS-278 (size designation A1). The barbed wires shall be given chromating dip as per procedure laid down in IS: 1340.

1.8.5 Danger, Number, Circuit and Phase plate

Danger plates, Number plates, Circuit plates and Phase plates shall be provided and installed by the Contractor.

a) Each tower shall be fitted with a danger plate, number plate and one set of phase plates for double circuit tower. Circuit plates shall be provided on all The Double Circuit towers.

b) The letters, figures and the conventional skull and bones of danger plates shall conform to IS-2551 and shall be in a signal red on the front of the plate.

c) The corners of the danger, number and circuit plates shall be rounded off to remove sharp edges.

d) The letters of number and circuit plates shall be red enameled with white enameled background.

1.8.6 Aviation Requirements

1.8.6.1 Aviation requirements viz Span marker, night marker (obstruction light) and painting of towers conforming to IS: 5613 shall be in the scope of Contractor, wherever indicated in BPS.

1.8.6.2 Night Markers (Obstruction lights)

1.8.6.2.1 The scope of night markers covers the design, manufacture, testing at manufacturers works, if any, supply, delivery, erection, testing and commissioning of medium intensity, low intensity, lights along with storage battery & solar panel, control panel, cables, clamps other accessories etc. as per the provision of IS-5613 (Part-II/ section-I), 1989, amendment no. 1, July'94 regarding night & day visual aids for denoting transmission line structures as per the requirement of directorate of flight safety.

1.8.6.2.2 The detail of each component of medium intensity, low intensity lights & associated accessories to be provided on the towers shall be as per the technical specifications given in the preceding clauses and IS/ICAO, International Standards recommended practices.

1.8.6.2.3 One set of Aviation Lights shall consist of one medium intensity light & two/four (as applicable) low intensity lights along with all accessories such as solar panel, control panel, batteries, cables etc.

1.8.6.2.4 **Medium Intensity Light**

Medium Intensity light shall be provided on the top of each tower. The medium light should have night time intensity as per ICAO requirements in international Standards Recommended Practices. The light on top of the structure should flash at the rate of 20 sequences per minute. The effective intensity during night time for the medium flashing light shall be 1600 CD. The light shall conform to ICAO requirements/BS 3224a and shall have weather protection conforming to IP-55.

The above lights conforming to ICAO specifications flashing red lights shall be DC operated through a suitably sized battery bank at the operating voltage 12V/24V DC. The burning life of the lamps shall be maximum possible in view of the maintenance hazard of H.T. live but in no case it should be less than 15,000 burning hours. In case of failure of the lamp before 15,000 burning hours, the same shall have to be replaced by the Contractor free of cost even if the pendency of contract expires. The light shall be equipped with radio suppression facility conforming to BS800 in order to avoid any interference with signals of PLCC etc.

1.8.6.2.5 **Low Intensity Lights**

Two/four (as applicable) nos. of low intensity lights are required to be put on each of the towers. Placement drawing for the same shall be submitted by the bidder Contractor.

The light shall be stationary lamp with minimum effective intensity of 10 CD. of red light. The lamps shall conform to the ICAO requirement/relevant BS and shall have weather protection of minimum IP-55 class.

Two/four nos. of L.I. lamp required for each tower shall be operated through a suitable size common battery bank solar panel as per the requirement of operating voltage and load current of the type of lamps being offered.

The burning life of the lamps shall be maximum possible in view of the maintenance hazard of H.T live line, but in no case it should be less than 15,000 burning hours. In case of failure of the lamp before 15,000 hrs, the same shall have to be replaced by the Contractor free of cost even if the pendency of contract expires. Performance certificate of the lamps to be offered shall be furnished by the Contractor.

The low intensity lamp shall not generate any R.F. which can interfere with the PLCC signals.

1.8.6.2.6 **Storage Battery**

Storage Battery required for the above purpose shall be sealed maintenance free, valve regulate lead acid and suitable for mounting on the top of the transmission line towers. Contractors shall offer the most optimum capacity of the Battery Bank at 120 hour discharge rate (considering 80 % percentage usage) matching with the load requirement of the type of lamps being offered including any power loss in the associated cables. The battery sizing shall conform to JISC 8707/relevant Indian Standard or any other internationally recognized standard. The battery shall be hermetically sealed explosion proof and self-resealing type and free from orientation constraints. The working temperature ranges shall be minimum 0 degree centigrade and maximum 50 degree centigrade. Performance certificate of the offered batteries shall be submitted by the Contractor.

1.8.6.2.7 **Battery Box**

The battery box suitable for mounting on 400kV power transmission tower shall be robust construction suitable to accommodate desired number of SOLAR BATTERIES WITH proper clearance between the batteries. The sides and the top of the battery box shall be made from MS sheets not less than 14 SWG thickness duly mounted on MS angle frame. The bottom of the battery box shall have suitably designed MS structure to freely hold the total weight of the batteries. The batteries should be placed on insulated base with proper drainage holes. Lifting lugs shall be provided. Dust and vermin proof lockable doors shall be provided for safety and easy access to the batteries for the maintenance. The battery box should incorporate the design for proper ventilation system in order to prevent a gas concentration inside the box. The ventilation opening shall be protected against rain/splash water and dust. The inside of the battery box shall be lined with insulating polyurethane plating and the exterior painted with weather proof polyurethane paint. The cable entry into the battery box shall be through suitable cable glands.

1.8.6.2.8 **Solar Modules**

Solar module required for the system shall be suitable for mounting on the transmission line towers and shall be designed for high performance, maximum reliability and minimum maintenance and shall be installed below bottom cross arms levels. The solar modules shall be IP 55 grade protection class. These should be highly resistant to water, abrasion, nail, impact and other environmental factors.

These should be placed on the tower at a most optimum angle so as to harness the maximum solar energy and facilitate self cleaning and shall conform to relevant Indian/International Standards.

Module mounting frames shall be weather proof suitable for mounting on tall towers. Details of mounting frames shall be furnished by the Contractor.

Junction box shall be provided with weather proof hinged lid with provision for cable glands entry and protections grade of class IP-55.

The Contractor shall submit the basis of selecting the numbers of solar modules.

The provision for design, supply & erection of mounting arrangements for photovoltaic modules on the transmission towers in a suitable manner to harness maximum solar energy shall be in the scope of the Contractor.

Provision for design, supply & erection of resting platform for the erection of battery bank in a closed enclosure with safety arrangement on the transmission towers shall also be in the scope of the Contractor the design and load consideration for safety of towers due to additional plate form shall be kept in view while designing, selecting the above.

1.8.6.2.9 **Control Panels**

Control panels shall consist of solar charge controller, flasher unit, sensor, isolator, MCB, Voltmeter, Ammeter and other control gears. Panel enclosure shall be fabricated out of 14 SWG CRCA sheet and thoroughly treated and painted. Suitable neoprene rubber gasket and pad locking device shall be provided and the protection class shall be of IP-55 class.

The Solar charge controller shall be most efficient and preferably fully solid state. It shall be provided with protection to load against increase in temperature, Surge, automatic low voltage and automatic disconnection and reconnection during high inrush current and normalcy respectively.

The flash regulator shall be provided for regulating light flashing. The same shall be completely solid state and provided with flash rate set points. The protection against overload current shall also be provided.

Necessary sensor/timer shall be provided in the system to "switch on" the light automatically in the evening and poor visibility period and switch off the same during day time and normal visibility period.

1.8.6.2.10 **Cables, Cable Glands, Conduits and Accessories**

The cable to be supplied and erected shall be of multi strands copper conductor, weather proof, PVC insulated PVC sheathed, armoured 1.1 KV grade. The same shall conform to IS:1554.

All the cable accessories such as thimble, glands etc. shall be in the scope of supply and erection of the Contractor.

Supply and erection of all the PVC conduits and accessories shall be in the scope of the contract. All the conduit and accessories shall be as per the relevant ISS or ISI brand.

The inter-connection cable/conduit will be clamped in a secured manner with the tower members and any interconnection should be made only inside the environmentally protected junction box.

1.8.6.2.11 **Earthing**

All the installations on the tower shall be securely and properly earthed with the tower body by using flexible copper braided wire. Cost of earthing material shall deemed to be included in the total cost.

1.9 Tower Fabrication

The fabrication of towers shall be in conformity with the following:

1.9.1 Except where hereinafter modified, details of fabrication shall conform to IS: 802 (Part-II) or the relevant international standards.

1.9.2 Butt splices shall be used and the inside angle and outside plate shall be designed to transmit the load. Inside cleat angle shall not be less than half the thickness of the heavier member connected plus 2mm. Lap splice may be used for connecting members of unequal sizes and the inside angle of lap splice shall be rounded at the heel to fit the root radius of the outside angle. All the splices shall develop full strength in the member connected through bolts. Butt as well as lap splice shall be made as above and as close to the main panel point as possible.

1.9.3 Joints shall be so designed as to avoid eccentricity as far as possible. The use of gusset plates for joining tower members shall be avoided as far as possible. However, where the connections are such that the elimination of the gusset plates would result in eccentric joints, gussets plates and spacers plates may be used in conformity with modern practices. The thickness of the gusset plates, required to transit stress shall not be less than that of members connected.

1.9.4 The use of filler in connection shall be avoided as far as possible. The diagonal web members in tension may be connected entirely to the gusset plate wherever necessary to avoid the use of filler and it shall be connected at the point of intersection by one or more bolts.

1.9.2 The tower structures shall be accurately fabricated to connect together easily at site without any undue strain on the bolts.

1.9.3 No angle member shall have the two leg flanges brought together by closing the angle.

1.9.4 The diameter of the hole shall be equal to the diameter of bolt plus 1.5mm.

1.9.5 The structure shall be designed so that all parts shall be accessible for inspection and cleaning. Drain holes shall be provided at all points where pockets of depression are likely to hold water.

1.9.6 All identical parts shall be made strictly inter-changeable. All steel sections before any work is done on them, shall be carefully leveled, straightened and made true to detailed drawings by methods which will not injure the materials so that when assembled, the adjacent matching surfaces are in close contact throughout. No rough edges shall be permitted in the entire structure.

1.9.7 Drilling and Punching

1.9.7.1 Before any cutting work is started, all steel sections shall be carefully straightened and trued by pressure and not by hammering. They shall again be trued after being punched and drilled.

1.9.7.2 Holes for bolts shall be drilled or punched with a jig but drilled holes shall be preferred. The punching may be adopted for thickness up to 16mm. Tolerances regarding punched holes are as follows:-

a) Holes must be perfectly circular and no tolerances in this respect are permissible.

b) The maximum allowable difference in diameter of the holes on the two sides of plates or angle is 0.8mm. i.e. the allowable taper in a punched holes should not exceed 0.8mm on diameter.

c) Holes must be square with the plates or angles and have their walls parallel.

1.9.7.3 All burrs left by drills or punch shall be removed completely. When the tower members are in position the holes shall be truly opposite to each other. Drilling or reaming to enlarge holes shall not be permitted.

1.9.8 Erection mark

1.9.8.1 Each individual member shall have erection mark conforming to the component number given to it in the fabrication drawings. The mark shall be marked with marking dies of 16mm size before galvanizing and shall be legible after galvanizing.

1.9.8.2 Erection Mark shall be A-BB-CC-DDD

A = Employer's code assigned to the Contractors- Alphabet

BB = Contractor's Mark-Numerical

CC = Tower Type Alphabet.

DDD = Number mark to be assigned by Contractor - Numerical.

Erection mark for high tensile steel members shall be prefixed by the letter "H"

1.10 Quantities and weights

1.10.1 The provisional quantity of towers & extensions are mentioned in the respective Schedule of Prices. Final quantities shall be determined after completion and approval of the tower spotting & check survey. The final quantities of tower shall be confirmed by the Employer based on the required quantities of various towers & extensions furnished by the Contractor after completion of final tower spotting & check survey. Hence, it will be responsibility of the Contractor to intimate the exact requirements of all towers and various line materials required for line immediately after the tower spotting & check survey.

The Employer reserves the right to order the final quantities including reasonable quantities of spares for which the rates quoted in the Bid shall be valid. Regarding quantity variation, the provisions of relevant clauses of SCC shall apply.

1.10.2 The estimated unit weight of each type of galvanized towers, stubs and leg extensions shall be furnished by the bidder. The weight of tower shall mean the weight of tower calculated by using the black sectional (i.e. un galvanized) weight of steel members of the size indicated in the approved fabrication drawings and bill of materials, without taking into consideration the reduction in weights due to holes, notches and bevel cuts etc. but taking into consideration the weight of the anticlimbing devices, D shackles, hangers, strain plates, pack plates, gusset plates and pack washers etc. The weight of gusset plates shall mean the weight of its circumscribing rectangle, without taking into consideration the reduction in weights due to holes, notches etc.. For bolts and nuts along with spring washers and step bolts, the weight per tower shall be calculated from the bolt schedule applicable to each type of towers, stubs and leg extensions as approved by the Employer. The rate quoted by the bidder for supply of tower / tower parts is deemed to be inclusive of galvanising charges including the cost of zinc.

1.10.3 The contractor is permitted to get inspected and supply up to 2.5% extra fasteners to take care of losses during erection. No payment shall be admissible for these extra supplies.

1.11 Galvanising

1.11.1 Fabricated Tower Parts & Stubs

The tower parts, stubs and pack washers shall be hot dip galvanized .The galvanization shall be done as per requirements of IS: 4759 after all fabrication work is completed. The contractor shall also take guidelines from the recommended practices for hot dip galvanizing laid down in IS 2629 while deciding and implementing galvanizing procedure. The mandatory requirements however, are specified herein.

Unless otherwise specified the fabricated tower parts and stubs shall have a minimum overall Zinc coating of 610 gms per sq. m of surface except for plates below 5mm which shall have Zinc coating of 460 gms per sq. m of surface. The average zinc coating for sections 5mm & above shall be maintained as 87 microns and that for sections below 5mm shall be maintained as 65 microns.

The zinc coating shall be adherent, reasonably uniform, smooth, continuous and free from imperfections such as black bare spots, ash rust stains, bulky white deposits / wet storage stains and blisters.

The surface preparation for fabricated tower parts and stubs for hot dip galvanizing shall be carried out as indicated herein below:

(i) Degreasing & Cleaning of Surface: Degreasing and cleaning of surface, wherever required, shall be carried out in accordance with clause 4.1 of IS 2629-1985. After degreasing the article shall be thoroughly rinsed. However, if acidic degreasers are used rinsing is not required.

(ii) Pickling: Pickling shall be done using either hydrochloric or sulfuric acid as recommended at clause 4.3 of IS 2629 -1985. The actual concentration of the acids and the time duration of immersion shall be determined by the Contractor depending on the nature of material to be pickled. Suitable inhibitors also shall be used with the acids to avoid over pickling. The acid concentration, inhibitors used, and maximum allowable iron content shall form part of plant standard to be formulated and submitted to Purchaser along with Quality Assurance Program.

(iii) Rinsing: After pickling, the material shall be rinsed, preferably in running water to remove acid traces, iron particles or any other impurities from the surface. Two rinse tanks are preferable, with water cascading from the second tank to the first to ensure thorough cleaning. Wherever single tank is employed, the water shall be periodically changed to avoid acid contamination, and removal of other residue from the tank.

(iv) Fluxing: The rinsed article shall be dipped in a solution of Zinc ammonium chloride. The concentration and temperature of the flux solution shall be standardized by the contractor depending on the article to be galvanized and individual circumstances. These shall form part of plant standard to be formulated and submitted to Purchaser along with Quality Assurance Program. The specific gravity of the flux solution shall be periodically monitored and controlled by adding required quantity of flux crystals to compensate for drag-out losses. Free acid content of the flux solution also shall be periodically checked and when it is more than two (2) grams of free acid per litre of the solution, it shall be neutralized. Alternatively, Ph value should be monitored periodically and maintained between 5 to 5.5

(v) Drying: When dry galvanizing is adopted the article shall be thoroughly dried after fluxing. For the purpose of drying, the contractor may use hot plate, air oven or any other proven method ensuring complete drying of the article after fluxing and prior to dipping in the molten zinc bath. The drying process shall be such that the article shall not attain a temperature at which the flux shall get decomposed. The article thus dried shall be galvanized before the flux coating picks up moisture from the atmosphere or the flux layer gets damaged or removed from the surface. The drying procedure, time duration, temperature limits, time lag between fluxing, drying, galvanizing etc shall form part of plant standard to be formulated and submitted to Purchaser along with Quality Assurance Program.

(vi) Quality of Zinc: Any one or combination of the grades of zinc specified in IS 209 or IS 13229 or other comparable international standard shall be used for galvanizing. The contractor shall declare the grade(s) of zinc proposed to be used by them for galvanizing. The molten metal in the zinc bath shall contain minimum 98.5 % zinc by mass. It shall be periodically measured and recorded. Zinc aluminum alloy shall be added as per IS 2629.

(vii) Dipping Process: The temperature of the galvanizing bath shall be continuously monitored and controlled. The working temperature of the galvanizing bath shall be maintained at 450+/ - 10 degree C .The article should be immersed in the bath as rapidly as possible without compromising on safety aspects. The galvanizing bath temperature, immersion angle & time, time duration of immersion, rate of withdrawal etc shall be monitored and controlled depending upon the size , shape, thickness and chemical composition of the article such that the mass of zinc coating and its uniformity meets the specified requirements and the galvanized surface is free from imperfections and galvanizing defects.

(viii) Post Treatment: The article shall be quenched in water. The quench water is to be changed / drained periodically to prevent corrosive salts from accumulating in it. If water quenching is not done then necessary cooling arrangements should be made. The galvanized articles shall be dipped in chromating solution containing sodium dichromate and sulfuric acid or chromic acid base additive at a predetermined concentration and kept at room temperature to retard white rust attack. The temperature of the chromate solution shall not exceed 65 degree C. The articles shall not be stacked immediately after quenching and dichromating. It shall be ensured that the articles are dry before any further handling operation.

(ix) Storing, Packing and Handling: In order to prevent white rust formation sufficient care should be exercised while storing handling and transporting galvanized products. The articles shall be stored in an adequately ventilated area. The articles shall be stored with spacers in between them and kept at an inclination to facilitate easy drainage of any water collected on the articles. Similar care is to be taken while transporting and storing the articles at site.

The Contractor shall prepare a detailed galvanizing procedure including Flow Chart with control parameters and all plant standards as required above and submit to Employer for approval as part of Quality Assurance Plan.

1.11.2. **Fasteners.**

For fasteners, the galvanizing shall conform to IS-1367(Part-13). The galvanizing shall be done with centrifuging arrangement after all mechanical operations are completed. The nuts, may however be tapped (threaded) or rerun after galvanizing and the threads oiled .The threads of bolts & nuts shall have a neat fit and shall be such that they can be turned with finger throughout the length of the threads of bolts and they shall be capable of developing full strength of bolts. Spring washers shall be electro galvanized as per Grade-IV of IS-1573.

1.12 Earthing

The Contractor shall measure the tower footing resistance (TFR) of each tower after it has been erected and before the stringing of the earth wire during dry weather. Each tower shall be earthed. The tower footing resistance shall not exceed 10 ohms. Pipe type earthing and counter poise type earthing wherein required shall be done in accordance with the latest additions and revisions of:

IS: 3043	Code of practice for Earthing.
IS: 5613	Code of practice for Design, Installation and maintenance (Part-II/Section-2) of overhead power lines.

1.12.1 *The cost for tower earthings shall be deemed to be included on somewhere in price schedule. No separate payment will be made.*

1.13 Inspection and Tests

1.13.1 General

All standard tests, including quality control tests, in accordance with appropriate Indian / International Standard, shall be carried out unless otherwise specified herein.

1.13.2 Inspection

1.13.2.1 a) The Contractor shall keep the Purchaser informed in advance about the time of starting and of the progress of manufacture and fabrication of various tower parts at various stages, so that arrangements could be made for inspection.

b) The acceptance of any part of items shall in no way relieve the Contractor of any part of his responsibility for meeting all the requirements of the Specification.

1.13.2.2 The Employer or his representative shall have free access at all reasonable times to those parts of the Contractor’s works which are concerned with the fabrication of the Employer's material for satisfying himself that the fabrication is being done in accordance with the provisions of the Specification.

1.13.2.3 Unless specified otherwise, inspection shall be made at the place of manufacture prior to dispatch and shall be concluded so as not to interfere unnecessarily with the operation of the work.

1.13.2.4 Should any member of the structure be found not to comply with the supplied design, it shall be liable to rejection. No member once rejected shall be resubmitted for inspection, except in cases where the Purchaser or his authorised representative considers that the defects can be rectified.

1.13.2.5 Defect which may appear during fabrication shall be made good with the consent of, and according to the procedure proposed by the Contractor and approved by the Employer.

1.13.2.6 All gauges and templates necessary to satisfy the Purchaser shall be supplied by the Contractor.

1.13.2.7 The specified grade and quality of steel shall be used by the Contractor. To ascertain the quality of steel used, the inspector may at his discretion get the material tested at an approved laboratory.

1.14 Tower Load Tests

The load test and destruction test are not envisaged. The Contractor is required to design the tower such as to withstand all conditions. The contractor shall be responsible for design and safety of the tower, and shall guarantee. However if testing is deemed to be required, the method to be followed is indicated as follows: The cost of such testing shall be included in the price of the tower.

1.14.1 Testing of Tower

A Galvanized tower of each type complete with 9 M extension shall be subjected to design and destruction tests by first applying test loads applied in a manner approved by the Employer. Multi-circuit towers shall be tested with 0M extension, i.e. normal tower. The tower shall withstand these tests without showing any sign of failure or permanent distortion in any part. Thereafter the tower shall be subjected to destruction by increasing the loads further in an approved manner till it fails. The tower shall be tested for all the conditions considered for the design of tower. The Contractor shall submit to the Employer, for approval, the detailed programme and proposal for testing the towers showing the methods of carrying out the tests and manner of applying the loads. After the Employer has approved the test procedures and programmes the Contractors will intimate the Employer about carrying out the tests at least 30 days in advance of the scheduled date of tests during which the

Employer will arrange to depute his representative to be present at the time of carrying out the tests. Six copies of the test reports shall be submitted. The Contractor shall submit one set of shop drawings alongwith the bill of materials at the time of prototype tower testing for checking the tower material. Further at the time of submitting test report, the contractor has to submit the final drawings of shop drawings and Bill of materials for Employer’s reference and record. The type testing charges shall be released only after approval of test report, structural drawings, bill of material and shop drawings of tower.

1.14.1.1 In case of premature failure the tower shall be retested and steel already used in the earlier test shall not be used again. However, in case of minor failures, the contractor can replace the members with higher section and carry out the testing. The Contractor shall provide facilities to the Employer or their representatives for inspection of materials during manufacturing stage and also during testing of the same.

1.14.1.2 In case of any premature failure even during waiting period, the tower is to be retested with rectified members. However, if the failures are major in nature and considerable portion of tower is to be re-erected, in such cases all the tests which has been carried out earlier are required to be re-conducted again in compliance with Specification.

1.14.1.3 No part of any tower subject to test shall be allowed to be used on the line. The price for the tower tests will be quoted after allowing rebate for the scrap value of the tower material which will be retained by the Contractor.

1.14.1.4 The Contractor shall ensure that the specification of materials and workmanship of all towers actually supplied conform strictly to the towers which have successfully under gone the tests. In case any deviation is detected, the Contractor shall replace such defective towers free of cost to the Employer. All expenditure incurred in erection, to and fro transportation and any other expenditure or losses incurred by Employer on this account shall be full born by the Contractor. No extension in delivery time shall be allowed on this account.

1.14.1.5 Each type of tower to be tested shall be a full scale prototype galvanized tower and shall be erected vertically on rigid foundation of the stub protruding above ground level as provided in the design/drawing between ground level and concrete level. This portion of the stub shall be kept un-braced while testing. The tower erected on test bed shall not be out of plumb by more than 1 in 360.

1.14.1.6 All the measuring instruments shall be calibrated in systematic / approved manner with the help of standard weight / device. Calibration shall be done before commencing the test of each tower up to the maximum anticipated loads to be applied during testing.

1.14.1.7 The suspension tower is to be tested with an arrangement similar to 'I' string. The tension tower is to be tested with strain plate as per approved design / drawings.

1.14.1.8 The sequence of testing shall be decided by the Employer at the time of approving the rigging chart / test data sheet.

1.14.1.9 The Employer may decide to carry out the tensile test, bend test etc. as per the relevant IS on few members of the test tower after completion of the test or in case of any premature failure. The Contractor shall make suitable arrangement for the same without any extra cost to the Employer.

1.14.1.10 Prefix 'T' shall be marked on all members of test tower in addition to the Mark No. already provided.

1.14.2 **Method of Load Application**

1.14.2.1 Loads shall be applied according to the approved rigging arrangement through normal wire attachments angles on bent plates.

1.14.2.2 The various types of loads, transverse, vertical and longitudinal shall be applied in such a way that there is no impact loading on the tower due to jerks from the winches.

1.14.2.3 All the loads shall be measured through a suitable arrangement of strain devices or by using weights. Positioning of the strain devices shall be such that the effect of pulley friction is eliminated. In case the pulley friction cannot be avoided, the same will be measured by means of standards weights and accounted for in the test loads.

1.14.3 **Tower Testing Procedure**

The procedure for conducting the tower test shall be as follows:

1.14.3.1 **Bolt Slip Test**

In a bolt slip test the test loads shall be gradually applied up to the 50% of design loads under normal condition, kept constant for two (2) minutes at that loads and then released gradually.

For measurement of deflection the initial and final readings on the scales(in transverse & longitudinal directions) before application and after the release of Loads respectively shall be taken with the help of theodolite. The difference between readings gives the values of the bolt slip.

1.14.3.2 **Normal Broken Wire Load Tests**

All the loads, for a particular load-combination test, shall be applied gradually upto the full design loads in the following steps and shall also be released in the similar manner:

25 percent,

50 percent,

75 per cent,

90 percent,

95 percent and

100 percent

1.14.3.3 Observation Periods

Under normal and broken wire load tests, the tower shall be kept under observation for sign of any failure for two minutes (excluding the time of adjustment of loads) for all intermediate steps of loading up to and including 95 percent of full design loads.

For normal, as well as broken wire tests, the tower shall be kept under observation for five (5) minutes (excluding the time for adjustment of loads) after it is loaded up to 100 percent of full design loads.

While the loading operations are in progress, the tower shall be constantly watched, and if it shows any tendency of failure anywhere, the loading shall be immediately stopped, released and then entire tower shall be inspected. The reloading shall be started only after the corrective measures are taken.

The structure shall be considered to be satisfactory, if it is able to support the specified full design loads for five (5) minutes, with no visible local deformation after unloading (such as bowing, buckling etc.) and no breakage of elements or constitute parts.

Ovalization of holes and permanent deformation of bolts shall not be considered as failure.

1.14.3.4 Recording

The deflections of the tower in transverse and longitudinal directions shall be recorded at each intermediate and final stage of normal load and broken wire load tests by means of a theodolite and graduated scale. The scale shall be of about one meter long with marking up to 5 mm accuracy.

1.14.3.5 Destruction Test

The destruction test shall be carried out under normal condition or broken wire condition. Under which load condition the destruction test is to be carried out shall be intimated to the contractor at the time of approving rigging chart / test data sheet.

The procedure for application of load for normal/broken wire test shall also be applicable for destruction test. However, the load shall be increased in steps of five (5) per cent after the full design loads have been reached.

1.15 Packing

1.15.1 Angle section shall be wire bundled.

1.15.2 Cleat angles, gusset plates, brackets, fillet plate, hanger and similar loose pieces shall be tied and bolted together in multiples or securely wired through holes.

1.15.3 Bolts, nuts washers and other attachments shall be packed in double gunny bags accurately tagged in accordance with the contents.

1.15.4 The contractor is required to suitably protect all steel members during shipment and storing to prevent damages to galvanized surfaces. The packing shall be properly done to avoid losses & damages during transit. Each bundle or package shall be appropriately marked.

1.16 Standards

1.16.1 The design, manufacturing, fabrication, galvanising, testing, erection procedure and materials used for manufacture and erection of towers, design and construction of foundations shall conform to the following Indian Standards (IS) / International Standards which shall mean latest revisions, with amendments / changes adopted and published, unless specifically stated otherwise in the Specification. In the event of supply of material conforming to Standards other than specified, the Bidder shall confirm in his bid that these Standards are equivalent to those specified. In case of award, salient features of comparison between the Standards proposed by the Bidder and those specified in this document will be provided by the Contractor to establish their equivalence.

1.16.2 The material and services covered under these specifications shall be performed as per requirements of the relevant standard code referred hereinafter against each set of equipment and services. Other internationally acceptable standards which ensure equal or higher performance than those specified shall also be accepted.

Sl. No.	Indian Standard	Title	International Standard
1.	IS:209-1992	Specification for Zinc	ISO/R/752 ASTM B6

Sl. No.	Indian Standard	Title	International Standard
2.	IS 278-1991	Galvanised Steel Barbed wire	ASTM A131
3.	IS 800-1991	Code of Practice for General Building Construction in Steel	CSA 6.1
4(a).	IS:802(Part 1) Sec 1-1995 Sec 2-1992	Code of Practice for General Building Construction in Steel in Overhead Transmission Line Tower : Materials, loads and Permissible Stress Section- 1: Materials and loads Section-2 : Permissible stresses.	ASCE 52 IEC 826 BS 8100
4(b).	IS:802(Part 2)-1990	Code of Practice for use of structural steel in Overhead Transmission Line : Fabrication, Galvanising, inspection & Packing	ASCE 52
4(c).	IS:802(Part 3)-1990	Code of Practice for use of structural steel in Overload Transmission Line: Tower testing	ASCE 52 IEC 652
5.	IS:808-1991	Dimensions for Hot Rolled Steel Beam, Column, Channel and Angle Sections.	
6.	IS:875-1992	Code of Practice for Design Loads (other than Earthquakes) for Buildings and Structures.	
7.	IS:1363-1990	Hexagon Nuts (size range M5 to M36)	
8.	IS:1367-1992	Technical Supply Conditions for Threaded Steel/ Fasteners	
9.	IS:1477-1990	Code of practice for Painting of Ferrous Metals in Buildings: Part-I: Pre-treatment Part-II: Painting.	
10.	IS:1573-1991	Electro-Plated Coatings of inc on iron and Steel	
11.	IS:1852-1993	Rolling and Cutting Tolerances of Hot	

Sl. No.	Indian Standard	Title	International Standard
		Rolled Steel Products	
12.	IS-1893-1991	Criteria for Earthquake Resistant Design of Structures	IEEE 693
13.	IS:2016-1992	Plain Washers	ISO/R887 ANSIB18-22.1
14.	IS:2062-1992	Steel for general structural purposes	
15.	IS:2074-1992	Ready Mixed Paint. Air Drying, Oxide. Zinc Chrome, Priming Specification.	
16.	IS:2551-1990	Danger Notice Plates	
17.	IS:2629-1990	Recommended Practice for Hot Dip Galvanising of iron and steel.	
18.	IS:2633-1992	Method of Testing Uniformity of Coating of Zinc Coated Articles	ASTM A123 CSA G164
19.	IS:3043-1991	Code of Practice for Earthing	
20.	IS:3063-1994	Single coil Rectangular section Spring Washers for Bolts, Nuts Screws	DIN-127
21.	IS:3757-1992	High Strength Structural Bolts	
22.	IS:4759-1990	Specification for Hot zinc coatings on structural steel and other Allied products	
23.	IS:5369-1991	General Requirements for Plain Washers	
24.	IS:5613-1993	Code of Practice for Design installation and Maintenance of Overhead Power Lines Section-1: Design Part 2, Section-2: Installation and Maintenance	
25.	IS:6610-1991	Specification for Heavy Washers for Steel structures	
26.	IS:6623-1992	High Strength Structural Nuts	

Sl. No.	Indian Standard	Title	International Standard
27.	IS:6639-1990	Hexagon Bolts for Steel Structure.	ASTM A394 ASTM A90
28.	IS:6745-1990	Method for Determination of weight of Zinc coated iron and Steel Articles.	ASTM A90
29.	IS:8500-1992	Specification for Weldable Structural Steel (Medium & High Strength Qualities)	
30.	IS:10238-1989	Step Bolts for Steel Structures	
31.	IS:12427-1988	Bolts for Transmission Line Towers	
32.		Indian Electricity Rules.	
33.	Publication No. 19(N)/700	Regulation for Electrical Crossing of Railway Tracks	

The standards mentioned above are available from

Reference Abbreviation	Name and Address
BIS/IS	Beureau Of Indian Standards. Manak Bhavan, 9, Bahadur Shah Zafar Marg, New Delhi - 110001. INDIA
ISO	International Organisation for Standardization. Danish Board of Standardization Danish Standardizing Sraat, Aurehoegvej-12 DK-2900, Heeleprup, DENMARK.

CSA	Canadian Standard Association 178, Rexadale Boulevard, Rexdale (Ontario) Canada, M9W 1R3
DIN	Deutsches Institute fiir Normung, Burggrafenstrassee 4-10 Post Farh 1107 D-1000, Berlin 30 GERMANY
ASTM	American Society for testing and Material 1916 Race Street Philadelphia. PA 1903-1187 USA
Indian electricity Rules Regulation for electricity crossing of railway Tracks	Kitab Mahal Baba Kharak singh Marg New Delhi-110001 INDIA
ASTM	American Society of civil Engineers 345 East 47th Street New York, NY 10017-2398 USA
IEEE	Institute of Electrical and Electronics Engineers 445 Hoes LanePiscataway, NJ 0085-1331, USA
IEC	International Electro technical Commission, Bureau Central de la Commission, electro Technique international, 1 Rue de verembe, Geneva SWITZERLAND

2.0 Foundations

2.1 The foundation shall generally be of open cast type. Reinforced Cement concrete footing shall be used for all types of towers in conformity with the present day practices and the specification laid herein. Footings for all the four legs (without unequal chimney extension) of the tower and their extension shall be similar, irrespective of down thrust and uplift.

2.2 Foundation includes supply of all labour, tools & machineries, materials such as cement, sand, coarse aggregates and reinforcement steel. Rates quoted for foundations in appropriate schedules shall include transportation of construction materials to site, excavation, stub setting, concreting, reinforcement, shoring, shuttering, dewatering, stock piling, dressing, curing, backfilling the foundation after concreting with excavated / borrowed earth (irrespective of leads), consolidation of earth and carriage of surplus earth to the suitable point of disposal as required by the Employer or any other activities related to completion of foundation works.

2.3 Classifications of Foundations

Classification of foundations and design of foundation depend upon the type of soil, sub- soil water level and the presence of surface water which have been classified as follows:

2.3.1 Normal dry

To be used for locations where normal dry cohesive or non-cohesive soils are met. Foundations in areas where surface water encountered from rain runoff shall also be classified as normal dry.

2.3.2 Sandy Dry Soil

To be used for locations where cohesion less pure sand or sand with clay content less than 10% met in dry condition. If the clay content is more than 10 % met in dry condition, the foundation shall be classified as Normal Dry.

2.3.3 Wet

To be used for locations where sub-soil water table is met between 1.5 meters from ground level and the depth of foundation below the ground level.

2.3.4 Wet Cultivated

To be used for locations where there is no sub-soil water within the foundation depth but which are in surface water for long period with water penetration not exceeding one meter below the ground level e.g paddy fields/cultivated field. However, if water penetration due to surface water is more than one meter below ground level, the adoption of suitable foundation shall be decided by site In-charge in consultation with corporate engineering deptt.

2.3.5 **Partially Submerged**

To be used at locations where sub-soil water table is met between 0.75 meter and 1.5metre below the ground level.

2.3.6 **Fully Submerged**

To be used at locations where sub-soil water table is met at less than 0.75 meter below the ground level.

2.3.7 **Black Cotton Soil**

To be used at locations where soil is clayey type, not necessarily black in colour, which shrinks when dry and swells when wet, resulting in differential movement. For designing foundations, for such locations, the soil is considered submerged in nature.

2.3.8 **Fissured - Rock**

To be used at locations where decomposed or fissured rock, hard gravel, kankar, limestone, laterite or any other soil of similar nature is met. Under cut type foundation is to be used for fissured rock locations.

In case of fissured rock locations, where water table is met at 1.5M or more below ground level, wet fissured rock foundations shall be adopted. Where fissured rock is encountered with subsoil water table less than 1.5 meter below ground level, submerged fissured rock foundations shall be adopted. In case of dry locations dry fissured rock foundations shall be adopted.

2.3.9 **Hard Rock**

The locations where chiseling, drilling and blasting is required for excavation for monolithic rock for a particular leg/tower, Hard rock type foundations are to be used. For these locations rock anchoring is to be provided to resist uplift forces.

For quoting prices of Hard Rock foundations, Rock level shall be assumed at 1.5 meters below the ground level. Due to change in Rock level, no extra payment shall be payable on account of increase in concrete volume, excavation volume and weight of reinforcement, also no recovery shall be made if the actual volume of concrete, excavation and weight of reinforcement are less than that quoted in Schedule of prices. However, for design purpose, Rock level shall be considered at ground level and no over burden soil weight shall be considered for resisting the uplift.

2.3.10 The sub-soil water table is not constant and its level changes during different seasons due to various factors. In case during soil investigation/trial pit or during excavation, if wet soil / fissures rock is encountered within the foundation depth, it is to be considered that water table has been encountered (considering that water table had reached that level sometime in past) and accordingly type of foundation shall be classified.

2.3.11 Where soil is of composite in nature, classification of foundation shall be according to the type of soil predominant in the foundation pit**.**

2.3.12 The foundation classification at any particular location shall be based on the type of soil (clay / sandy / silt / fissured rock etc) and water table, presence of surface water, etc. at the location. However, in case of locations which are in vicinity of rivers, depending upon case to case, type of foundation is to be decided considering other aspects also e.g in case RL (reduced level) of a location in comparison to the HFL is lower and there is possibility of submergence at the time of floods due to absence of river bunds / protection etc., FS type foundation with suitable raised chimney is to be adopted. Further in case there is a possibility of change in river course, considering the nature and turbulence of probable water flow and subsequent scouring of soil, pile type or special foundation may be considered for these locations.

2.3.13 In addition to above, if required, depending on the site conditions special type foundations shall also be provided by the contractor suitable for intermediate conditions under the above classifications to effect more economy for following reasons:

(a) Shallow Depth or Raised Chimney foundations are necessarily required to suit the site condition or
(b) Soil properties as per the soil report at particular location are found inferior than that considered in design . However, in case ,soil properties as per soil report are found superior than that considered in design ,no change in foundation design / price shall be applicable.

2.4 Type of Foundations

The Bidder shall offer open type of foundation (i.e. slab and chimney) with maximum depth of foundation as 3.0 meters for above classification of foundations depending on economy and feasibility of construction at site.

Bidder has to furnish along with the bid one sample calculation for each type of foundation required as per BPS for verification of correctness of design procedure adopted by the Bidder.

2.5 Soil Investigation

The contractor shall undertake soil investigation at tower locations as approved by the Employer.

2.6 Design of Foundations

2.6.1 Loads on Foundations

2.6.1.1 The foundations shall be designed to withstand the specific loads of the superstructure and for the full footing reactions obtained from the structural stress analysis in conformity with the relevant factors of safety.

2.6.1.2 The reactions on the footings shall be composed of the following type of loads for which these shall be required to be checked:

a) Max. Tension or uplift along the leg slope.

b) Max. Compression or down-thrust along the leg slope.

c) Max. Horizontal shear or side thrust.

2.6.1.3 Overload Factor for Foundation Loads:

The overload factor for foundation loads shall be considered as 1.1 i.e. the reaction on the foundations shall be increased by 10 percent.

2.6.2 Stability Analysis

2.6.2.1 In addition to the strength design, stability analysis of the foundation shall be done to check the possibility of failure by over-turning, uprooting, sliding and tilting of the foundation.

2.6.2.2 The following primary types of soil resistance shall be assumed to act in resisting the loads imposed on the footing in earth:

A) Resistance Against Uplift

The uplift loads will be assumed to be resisted by the weight of earth in an inverted frustum of a conical pyramid of earth as per formula detailed in Annexure –A of this Section on the footing pad whose sides make an angle equal to the angle of repose of the earth with the vertical, in average soil. The weight of concrete embedded in earth and that above the ground will also be considered for resisting the uplift. In case where the frustum of earth pyramids of two adjoining legs super-imposed each other, the earth frustum will be assumed truncated by a vertical plane passing through the centre line of the tower base.

B) Resistance Against Down Thrust

The down-thrust loads combined with the additional weight of concrete above earth will be resisted by bearing strength of the soil assumed to be acting on the total area of the bottom of the footings.

C) Resistance Against Side-Thrust

The lateral load capacity of a chimney foundation shall be based on chimney acting as a cantilever aided by passive earth resistance developed 500 mm below the ground level.

The chimney shaft shall be reinforced for the combined action of axial force, tension and compression and the associated maximum bending moment. In these calculations, the tensile strength of concrete shall be ignored. Similarly, since stub angle is embedded in the centre of the chimney, its effectiveness in the reinforcement calculation is to be ignored.

The increase in vertical toe pressure due to maximum bending moment at the bottom of the slab shall be taken into account and the base itself shall be designed for structural adequacy. In this case, the allowable vertical toe pressure may be increased by 25%. The unit weight of reinforced concrete is stipulated in Table 2-2.

2.7 Design Criteria

2.7.1 As per IS: 456-2002 Partial safety factor shall be considered 1.5 for concrete and 1.15 for steel.

2.7.2 The overload factors for open type foundations shall be as 1.1 i.e. all the reactions (compression, tension and side thrust) on foundations shall be increased by 10 percent for development of foundation design.

2.7.3 The physical properties of soil under various conditions are furnished in TABLE 2.3 to be considered for the design of foundations. These type of foundations correspond to list of foundations furnished in Schedule of prices VOL III.

2.7.4 The foundation shall be designed such as to satisfy the following conditions:

2.7.5 The thickness of concrete in the chimney portion of the tower footing would be such that it provides minimum cover of not less than100 mm from any part of the stub angle to the nearest outer surface of the concrete in respect of all dry locations limiting the minimum section of chimney to 300 mm square .In respect of all wet location, the chimney should have all around clearance of 150 mm from any part of stub angle limiting to 450 mm square minimum.

2.7.6 The chimney top or muffing must be at least 225 mm above ground level and also the coping shall be extended up to lower most joint level between the bottom lattices and the main corner legs of the tower. .

2.7.7 The centroidal axis of slab shall coincide with the axis of the chimney and pass through the center of foundation base. The design of the foundation(base slab and its reinforcement) shall take into account the additional stresses in the foundation resulting from the eccentricity introduced due to non-compliances of this requirement.

2.7.8 At least 100 mm thick pad of size equal to the base of slab with its sides vertical will be provided below the slab for R.C.C. type foundations.

2.7.9 In case of reinforced concrete slab, the slab thickness should not be less than 300 mm.

2.7.10 The minimum distance between the lowest edge of the stub angle and the bottom surface of concrete footing shall not be less than 100 mm or more than 150 mm in case of dry locations and not less than 150 mm or more than 200 mm in case of wet locations.

2.7.11 The total depth of open type foundations below the ground level shall not be less than 1.5 meters and more than 3.0 meters. To maintain the interchangeability of stubs for all types of foundations, for each type of tower, almost the same depths of foundations shall be used for different types of foundations.

2.7.12 The portion of the stub in the slab shall be designed to take full down-thrust or uplift loads by the cleats combined with the bond between stub angles and slab concrete. The Contractor shall furnish the calculation for uprooting of stub along with the foundation design. Bolted cleat angles evenly spaced in sets of 4 along all sides of embedded portion of the stub shall be provided to act as shear connector with sufficient number of bolts.

2.7.13 In case of R.C.C. foundations are having steel reinforcement in base slab, at least 50 mm. thick pad of lean concrete corresponding to 1:3:6 nominal mixes shall be provided to avoid the possibility of reinforcement rod being exposed due to unevenness of the bottom of the excavated pit.

2.7.14 The base slab of the foundation shall be designed for additional moments developing due to eccentricity of the loads.

2.7.15 The additional weight of concrete in the footing below ground level over the earth weight and the full weight of concrete above the ground level in the footing and embededded steel parts will also be taken into account adding to the down thrust.

TABLE 2.3

PROPERTIES OF SOIL	ULTIMATE BEARING CAPACITY KN/M2(Kg/M2)	ANGLE OF REPOSE DEGREE
1. For Normal Soil		
(a) Normal Dry Soil	**268 (27350)**	**25**
(b) Wet Soil Due to Presence of Subsoil/Surface Water	134 (13675)	15
1a. **SANDY SOIL**		
(a) Sandy Soil	**268 (27350)**	**20**

2. WEIGHT OF EARTH for Normal soil	**UNIT**	**VALUE**
(a) Dry	KN/M3 (Kg/M3)	14.12 (1440)
(b) In presence of Surface Water	KN/M3 (Kg/M3)	14.12 (1440)
(c) In presence of Subsoil Water	KN/M3 (Kg/M3)	9.22 (940)
3. FISSURED ROCK		
(a) Ultimate Bearing Capacity (both for Dry & Wet Fissured Rock)	KN/M2 (Kg/M2)	498 (50800)
(b) WEIGHT OF FISSURED ROCK		
i) Dry	KN/M3 (Kg/M3)	14.12 (1440)
ii) In presence of Subsoil Water	KN/M3 (Kg/M3)	9.22 (940)
(c) ANGLE OF REPOSE		
i) Fissured Rock in Dry Portion	Degrees	20
ii) Fissured Rock in Presence of Water	Degrees	10
4. HARD ROCK		
a) Ultimate Bearing Capacity	KN/M2 (Kg/M2)	1225.83 (125000)

b) Ultmate Bond between steel KN/M2 (Kg/M2) 0.147 (15)

The above soil properties of the earth will be measured by the Contractor at the various locations in conformity with the standard method of testing and the foundation design will be revised suiting the site conditions from such tests.

2.8 Properties Of Concrete

The cement concrete used for the foundations shall generally be of grade M-20 having 1:1.5:3 nominal volumetric mix ratio with 20mm coarse aggregate for chimney portion and 20mm/40mm aggregates for pyramid or slab portion. *Same shall be decided during Detailed engineening.* All the properties of concrete regarding its strength under compression, tension, shear, punching and bending etc. as well as workmanship will conform to IS:456.

2.8.1 The weight of concrete to be considered for design of foundations is given in TABLE 2-2.

TABLE 2.2

WEIGHT OF CONCRETE .

TYPE OF CONCRETE	WEIGHT OF DRY REGION KN / M3(Kg/m3)	WEIGHT IN PRESENCE OF SUB-SOIL WATER KN / M3(Kg/m3)
Plain Concrete	21.96 (2240)	12.16 (1240)
Reinforced Concrete	23.54 (2400)	13.73 (1400)

2.8.2 The Quantity of minimum cement to be used per unit quantity of consumption for different mix (nominal mix) of concrete should be as follows:

Sl.no.	Description	Unit	Quantity of Minimum cement to be used perUnit quantity of work (in kgs)
1.	1:1.5:3 nominal mix concrete	Cu.m.	400
2.	1:2:4 nominal mix concrete	Cu.m.	320
3.	1:3:6 nominal mix concrete	Cu.m.	220
4.	Random Rubble Masonry with 1:6 cement mortar	Cu.m.	83

In this regard utilisation record is to be maintained at site.

2.8.3 Alternatively, Ready Mix concrete from batching plant as per IS 4925 can also be used used with no extra payment and without any recovery. However Cement content shall be as per IS 456. The ready mix concrete shall conform to IS:4926. The selection and use of Materials for the ready mix concrete shall be in accordance with IS:456. The concrete shall be of M20 grade design mix as per IS:456. *Same shall be decided during Detailed engineering.* The transport of concrete and transportation time shall be as per IS:4926.

2.8.4 a) Cement used shall be ordinary Portland Cement, unless mentioned otherwise, conforming to the latest Indian Standard Code IS:269 or IS:8112 or IS:12269.

b) Alternatively, other varieties of cement other than ordinary Portland Cement such as Portland Pozzolana Cement conforming to IS;1489 (latest edition) or Portland Slag Cement conforming to IS:455 (Latest edition) can also be used. The Contractor shall submit the manufacturer's certificate, for each consignment of cement procured, to the Employer. However Employer reserves the right to direct the Contractor to conduct tests for each batch/lot of cement used by the Contractor and Contractor will conduct those tests free of cost at the laboratory so directed by the Employer. The Contractor shall also have no claim towards suspension of work due to time taken in conducting tests in the laboratory. Changing of brand or type of cement within the same structure shall not be permitted without the prior approval of the Employer. Sulphate Resistant Cement shall be used if sulphate content is more than the limits specified in IS: 456, as per Geotechnical investigation report.

The curing time of cement will be decided at the time of execution of the work under the contract based on the certificate from a reputed laboratory which will be obtained and submitted by the Contractor.

2.8.5 Concrete aggregates shall conform to IS: 383-1970.

2.8.6 The water used for mixing concrete shall be fresh, clean and free from oil, acids and alkalies, organic materials or other deleterious substances. Potable water is generally preferred.

2.8.7 Reinforcement shall conform to IS: 432-1966 for M.S bars and hard drawn steel wires and to IS: 1138-1966 and IS: 1786-1966 for deformed and cold twisted bars respectively. The grade of steel shall be Fe500. All reinforcement shall be clean and free from loose mill scales, dust, loose rust, and coats of paint, oil or other coatings, which may destroy or reduce bond. Contractor shall supply, fabricate and place reinforcement to shapes and dimensions as indicated or as required to carry out intent of drawings and specifications.

2.9 Measurement ,Unit Rates and Payment for Foundation

2.9.1 Measurement

2.9.1.1 The concrete volume and dimensions of the foundation shall be determined from the drawing approved. Measurement of concrete volume shall be in cubic meters and shall be worked out to the second place of decimal

2.9.1.2 The excavation volumes for each tower footing shall be estimated assuming the faces of surrounding earth as vertical keeping a distance of 150 mm clearances from the extreme edge of the base slab of footing. For footings with undercut, excavation volumes shall be calculated as per drawings without any side clearance.

2.9.1.3 The steel required for reinforcement of foundation shall be provided by the Contractor. Measurement will be based on the calculated weights of actually used in tonnes corrected to third place of decimal, no allowance being made for wastage. No payments will be made for wire required for binding the reinforcement, chairs, bolsters and spacers, as the cost of these is deemed to be included in the unit rate quoted for the item of reinforcement.

2.9.2 UNIT RATE

2.9.2.1. The unit rates of excavation for each type of soil shall include excavation along with all associated activities like shoring, shuttering, dewatering till completion of foundation work stock piling, dressing, back filling of foundations after concreting with excavated/borrowed earth (irrespective of lead) and consolidation of earth, carriage of surplus earth to the suitable point of disposal as required by the Employer or any other activity related to completion foundation work in all respect.

2.9.2.2 Form boxes shall be used for casting of foundations. The unit rate of concreting shall include the cost of supply, fabrication and placement of form boxes, cement, water, coarse and fine aggregates mixing and placing of concrete, curing of concrete and any other activities related to completion of concreting works of foundation.

2.9.2.3 The unit rate of 'Reinforcement Steel' shall include supply and placement of reinforcement steel, stirrups, wire for binding the reinforcement, chairs, bolsters and spacers etc. as required to complete the foundation work.

2.9.3 Payment for Foundation

2.9.3.1—— Excavation

The measurement for this item shall be made on the basis of design excavation volume arrived at considering dimension of pit leaving 150mm gap around (except for under cut foundations) the base pad or actually excavated whichever is less and the unit rate of this item as indicated in Contract. The payment for excavation shall be made as per actual type of soil encountered at the time of excavation, but the total payment for excavation portion shall not exceed the amount as payable for excavation considering the soil type same as that of foundation classification. The decision of the Employer shall be final and binding with respect to classification of soil and foundations. In case unit rates for the same soil type under different tower types are different then the lowest rate among them shall be used for the payment purpose.

2.9.3.2 Concrete

The payment for this item shall be made as per the actual volumes of concreting but limited to design volume based on unit rates for these items indicated in Contract.

2.9.3.3 Reinforcement

The measurement of reinforcement steel for payments shall be made based on the calculated weight of reinforcement steel as per relevant Indian Standard actually used in tones corrected to third place of decimal as calculated weight of steel as per design / working drawing whichever is less. No allowance will be made for wastage and others.

2.10 CONSTRUCTION OF TOWER FOUNDATION

2.10.1 TESTING OF SOIL

2.10.1.1 The Contractor shall be required to undertake testing of soil for the tower and shall submit his report about the subsoil water table, type of soil encountered, bearing capacity of soil, possibility of submergence and other soil properties required for the design of foundations. The Contractor shall also furnish soil resistivity values to the Employer along the line alignment.

2.10.2 Excavation

2.10.2.1 The excavation work for foundations shall be taken up by the Contractor after obtaining approval from Employer for the proposed stretch wise / section wise tower schedule, profile etc. prepared during Check / Detailed survey along the approved route alignment.

2.10.2.2 Except as specifically otherwise provided, all excavation for footings shall be made to the lines and grades of the foundations. The excavation wall shall be vertical and the pit dimensions shall be based on an assumed clearance of 150mm on all sides of the foundation pad. For footings with undercut, care shall be taken to carry out excavation as per drawings without any side clearance. All excavation shall be protected so as to maintain a clean sub grade and provide worker safety until the footing is placed, using timbering, shoring, shuttering, dewatering etc. as approved by the Employer. Contractor shall especially avoid disturbing the bearing surface of the pad. Any sand, mud, silt or other undesirable materials which may accumulate in the excavated pit or borehole shall be removed by Contractor before placing concrete.

2.10.2.3 The soil to be excavated for tower foundations shall be classified as follows depending upon the physical state of the soil at the time of excavation irrespective of the type of foundation installed:

a) Dry Soil

Soil removable either manually, means of a spade and shovel or mechanically by proclains, excavator etc. Excavation done in dry soil for wet and fully submerged type of foundations shall also be covered under this.

b) Wet Soil

Where the subsoil water table is encountered within the range of foundation depth or land where pumping or bailing out of water is required due to presence of surface water shall be treated as wet soil. The excavation done in wet soil in case of wet and fully submerged type of foundation shall also be covered under this.

c) Dry Fissured Rock

Limestone, laterite, hard conglomerate or other soft or fissured rock in dry condition which can be quarried or split with crowbars, wedges, pickaxes or by mechanical shovels etc. However, if required, light blasting may be resorted to for loosening the material but this will not in any way entitle the material to be classified as hard rock.

d) Wet Fissured Rock

Above fissured rock, when encountered with subsoil water within the range of foundation depth or land where pumping or bailing out of water is required, shall be treated as wet fissured rock.

e) Hard Rock

Any rock excavation, other than specified under fissured rock above, for which blasting, drilling, chiseling are required. The unit rate quoted for hard rock excavation shall be inclusive of all costs for such drilling (including drilling required for anchoring), chiseling and blasting, etc.

2.10.2.4 However, where soil is of composite in nature, classification of foundation shall be according to the type of soil predominant in the footing and payment shall be made accordingly.

2.10.2.5 No extra payment shall be admitted for the removal of fallen earth into a pit or borehole once excavated. Shoring and timbering / shuttering as approved by authorised representative of the Employer shall be provided by the Contractor when the soil condition is so bad that there is likelihood of accident due to the falling of earth.

2.10.2.6 Where rock is encountered, the holes for tower footings shall preferably be drilled. Blasting where resorted to as an economy measure, if permitted by the Employer shall be done with utmost care to minimise fracturing of rock and using extra concrete for filling the blasted area. All necessary precautions for handling and use of blasting materials shall be taken. In cases where unnecessarily large quantities are excavated / blasted, resulting in placement of large volumes of concrete, payment of concrete shall be limited to design volumes of excavation, concreting, reinforcement etc. In case where drilling is done, the stubs may be shortened suitably with the approval of the Employer or his authorised representatives.

2.10.2.7 The Contractor shall arrange & supply requisite blasting material, and be responsible for its storage and use, without any extra cost to the Purchaser.

2.10.3 Setting of Stubs

2.10.3.1 For all towers the Contractor shall submit for approval the proposed method for setting of stubs.

2.10.3.2 The stubs shall be set correctly and precisely in accordance with approved method at the exact location, alignment and levels with the help of stub setting templates and leveling instruments. Stubs setting shall be done in the presence of Employer's representative available at site where required and for which adequate advance intimation shall be given to Employer by Contractor. Tolerances as per provisions of IS: 5613 shall be allowed for stub setting.

2.10.3.3 Setting of stub at each location shall be approved by Employer.

2.10.3.4 However, in hilly region for towers with unequal leg extensions props may be used with complete accuracy and high skilled supervision, subject to prior approval from Employer.

2.10.3.5 As per the schedule testing of all four towers must be completed before the start of casting foundations. However, for any reason if the testing of tower gets delayed Contractor shall not hold the casting of foundation work and shall cast the foundations with the stub of untested tower as per the design at his own risk and cast. Accordingly Contractor shall keep enough safety while choosing the section for the stub /leg of last panel of tower to ensure that that the section for stub / leg of last panel shall not change during completion of tower testing.

2.10.4 Stub Setting Templates / Props

2.10.4.1 Stub setting templates shall be designed and arranged by the Contractor at his own cost for all types of towers with or without body extension. Stub templates for standard towers and towers with body extension upto 9 M shall be of adjustable type. The Contractor shall also arrange for props for setting of stubs at specific locations where use of prop is approved by the Employer. Stub templates / props should be painted.

2.10.4.2 The Contractor shall deploy sufficient number of templates / props (where ever required) for timely completion of the line without any extra cost to Employer.

2.10.4.3 One set of each type of stub setting template **/** props (if used) shall be supplied to the Employer, on completion of the project, at no extra cost to Employer.

2.10.4.4 Generally for a transmission line following number of stub setting templates shall be deployed by the Contractor:

Templates for tower type	**Nos. to be deployed**
For each type of DA, DB, DC and DD/DDS type	3 templates for each type of tower

However, if Employer feels that more templates are required for timely completion of the lines, the Contractor shall have to deploy the same without any extra cost to Employer.

The number of sets of prop (if permitted) to be supplied, will depend as per actual site condition and completion schedule of line.

2.10.5 Mixing, Placing and Compacting of Concrete

2.10.5.1 The concrete shall be mixed in the mechanical mixer. However, in case of difficult terrain, hand mixing may be permitted at the discretion of the Employer. The water for mixing concrete shall be fresh, clean and free from oil, acids and alkalis. salty or blackish water shall not be used.

Alternatively, Ready Mix concrete from batching plant as per IS 4925 can also be used used with no extra payment and without any recovery. However Cement content shall be as per IS 456. The ready mix concrete shall conform to IS:4926. The selection and use of Materials for the ready mix concrete shall be in accordance with IS:456. The concrete shall be of M20 grade design mix as per IS:456. The transport of concrete and transportation time shall be as per IS:4926.

2.10.5.2 Mixing shall be continued until there is uniform distribution of material and mix is uniform in colour and consistency, but in no case the mixing be carried out for less than two minutes. Normal mixing shall be done close to the foundation but exceptionally, in difficult terrain**,** the concrete may be mixed at the nearest convenient place. The concrete shall be transported from the place of mixing to the place of final deposit as rapidly as practicable by methods which shall prevent the segregation or loss of any ingredient. The concrete shall be placed and compacted before setting commences.

2.10.5.3 To avoid the possibility of reinforcement rods being exposed due to unevenness of the bottom of the excavated pit, a pad of lean concrete 50mm thick and corresponding to a 1:3:6 nominal mix shall be provided at the bottom of the pad.

2.10.5.4 Form boxes shall be used for casting all types of foundations except at an undercut interface for which the adjoining subsurface material shall provide adequate support.

2.10.5.5 The concrete shall be laid down in 150mm layers and consolidated well, so that the cement cream works, up to the top and no honey-combing occurs in the concrete. A mechanical vibrator shall be employed for compaction of the concrete. However, in case of difficult terrain, manual compaction may be permitted at the discretion of the Employer. Monolithic casting of foundations must be carried out. However, in case of unavoidable circumstances, a key construction joint can be provided at the chimney-pad interface subject to approval of the Employer. However nothing extra shall be paid to the Contractor for providing such construction joints. After concreting the chimney portion to the required height, the top surface should be finished smooth with a slight slope towards the outer edge for draining rain water.

2.10.5.6 Wet locations shall be kept completely dewatered, both during and 24 hours after placing the concrete, without disturbance of the concrete.

2.10.5.7 If minor defects in concrete surface is found after the form work is removed, the damage shall be repaired with a rich cement sand mortar to the satisfaction of the Employer before the foundation is back filled.

2.10.6 Curing

The concrete shall be cured by maintaining the concrete wet continuously for a period of at least 10 days after placing. Once the concrete has set for 24 hours the pit may be backfilled with selected moistened soil and well consolidated in layers not exceeding 200mm thickness and thereafter both the backfill earth and exposed chimney shall be kept wet for the remainder of the prescribed 10 days. The exposed concrete chimney shall also be kept wet by wrapping empty gunny bags around it and wetting the bags continuously during the critical 10 days period.

2.10.7 Backfilling and Removal of Stub Templates

2.10.7.1 After opening of formwork and removal of shoring, timbering, etc., backfilling shall be started after repairs, if any, to the foundation concrete. Backfilling shall normally be done with the excavated soil, unless it is a clay type or it consists of large boulders/stones, in which case the boulders shall be broken to a maximum size of 80-mm. At locations where borrowed earth is required for backfilling, Contractor shall bear the cost irrespective of leads & lift.

2.10.7.2 The backfilling materials shall be clean and free from organic or other foreign materials. A clay type soil with a grain size distribution of 50% or more passing the number 200 sieve as well as a black cotton soil is unacceptable for backfilling. The earth shall be deposited in maximum 200mm layers, leveled, wetted if necessary and compacted properly before another layer is deposited. The moisture content for compaction shall be based on the Proctor compaction test results given in the Geo-technical Report, Clause 3.0 of section 3. The density of the compacted backfill material may further be verified to the satisfaction of the Employer based on the sand-cone method described in the ASTM D1556-82 standard.

2.10.7.3 The backfilling and grading shall be carried to an elevation of about 75mm above the finished ground level to drain out water. After backfilling 50mm high, earthen embankment (Bandh) will be made along the sides of excavation pits and sufficient water will be poured in the backfilling earth for at least 24 hours. After the pits have been backfilled to full depth the stub template can be removed.

2.10.8 Benching

When the line passes through hilly / undulated terrain, leveling the ground may be required for casting of tower footings. All such activities shall be termed benching and shall include cutting of excess earth and removing the same to a suitable point of disposal as required by Employer. Benching shall be resorted to only after approval from Employer. Volume of the earth to be cut shall be measured before cutting and approved by Employer for payment purposes. Further, to minimize benching, unequal leg extensions shall be considered and provided if found economical. If the levels of the pit centers be in sharp contrast with the level of tower centre, suitable leg extensions may be deployed as required. The proposal shall be submitted by the Contractor with detailed justification to the Employer.

2.10.9 Protection of Tower and Tower Footing

2.10.9.1 Tower shall be spotted such that the quantity of revetment is optimum. For tower locations in undulated terrain such as hill / mountain slopes, options like use of unequal leg extensions for towers, unequal chimney extensions etc. shall be explored by the contractor for optimizing the need for revetment & benching.

2.10.9.2 The work shall include all necessary stone revetments, concreting and earth filling above ground level, the clearing from site of all surplus excavated soil, special measures for protection of foundation close to or in small water streams (Nalas), river bank / bed, undulated terrain, protection of up hill / down hill slopes required for protection of tower etc., including suitable revetment or galvanised wire netting and meshing packed with boulders. The top cover of stone revetment shall be sealed with M-15 concrete (1:2:4 mix). Contractor shall recommend protection at such locations wherever required. Details of protection of tower/tower footing are given in drawing enclosed with these specifications for reference purpose only.

2.10.9.3 In protection of tower footings works the backfilling shall generally be done using soil excavated at site unless deemed unsuitable for backfilling. In the latter case, backfilling shall be done with borrowed earth of suitable quality irrespective of leads and lift. The unit rate for backfilling quoted in Price Schedules shall include the required lead and consolidation and leveling of earth after backfilling.

2.10.9.4 The provisional quantities for protection work of foundations are furnished in Price Schedule of Bid . The unit rates shall also be applicable for adjusting the actual quantities of protection works done. These unit rates shall hold good for protection work carried out on down hills or up hills slopes applicable for the tower locations.

2.10.9.5 The unit rates for random rubble masonry revetment quoted in price schedule shall also include excavation & (1:5) random masonry and unit rate for top sealing with M-15 concrete. For payment purposes the volume of random rubble masonry revetment shall be measured from bottom to top sealing coat and paid at the quoted rates indicated in price schedule.

No extra rates shall be paid for allied work such as excavation, for revetment, packed stone at head of weep holes etc. However, no deduction shall be made for the volume enclosed by weep holes. The locations where both benching and protection of tower footing are envisaged, an economy got to be established against providing unequal leg extension.

2.10.9.6 For some of the locations in small water streams (Nalas), river bed or undulated terrain etc., boulders of minimum. 150mm size bounded and packed in galvanised wire net / mesh of 8 SWG wire and 152 square (maximum) mesh are to be provided. These stones shall be provided in crates size of 2.0mx2.0m or as deemed suitable for a particular location. Measurement shall be taken in cubic meters and 15% deduction will be made for void from cage / stack measurements.

3.0 Tower Erection, Stringing and Installation of Line Materials

3.1 General

3.1.1 The scope of erection work shall include the cost of all labour, tools and plant such as tension stringing equipment and all other incidental expenses in connection with erection and stringing work. The bidders shall indicate in the offer the sets of stringing equipment he would deploy exclusively for this transmission line package. The stringing equipment shall be of sufficient capacity to string simultaneously a bundle of QUAD MOOSE Conductors.

3.1.2 The Contractor shall be responsible for transportation to site of all the materials to be provided by the Contractor as per the scope of work to site, proper storage and preservation at his own cost, till such time the erected line is taken over by the Employer.

3.1.3 Contractor shall set up required number of stores along the line and the exact location of such stores shall be discussed and agreed upon with the Employer. Purchaser supplied items shall be dispatched to nearest store set up by the Contractor. At the store receipt, unloading and further transportation to the site shall be the entire responsibility of the Contractor.

3.1.4 Payment for Tower Erection and Conductor stringing works shall be done as mentioned in Chapter-1, PSR

3.2 Treatment of Minor Damage in Galvanisation

Minor defects in hot-dip galvanised members shall be repaired by applying zinc rich primer and two coats of enamel paint to the satisfaction of the Employer before erection.

3.3 Assembly of Tower

The Contractor shall give complete details of the erection procedures he proposes to follow.

3.3.1 The method for the erection of towers shall ensure the following:

a) Straining of the members shall not be permitted for positioning. It may, however, be necessary to match hole positions at joints using Tommy bars not more than 450 mm in length.

b) Prior to erection of an upper section, the lower sections shall be completely braced, and all bolts provided tightened adequately in accordance with approved drawings to prevent any mishap during tower erection.

c) All plan diagonals, oblique bracings etc for relevant section of tower shall be in place prior to assembly of an upper Section.

d) The bolt positions in assembled towers shall be as per IS: 5613 (Part II/Section 2).

e) Tower shall be fitted with number plates, danger plates, phase plates, Circuit Plates and anti-climbing device as described.

f) After complete erection of the tower, all blank holes, if any, are to be filled by bolts and nuts of correct size.

3.4 Tightening of Bolts and Nuts

3.4.1 All nuts shall be tightened properly using correct size spanner and torque wrench. Before tightening, it will be verified that filler washers and plates are placed in relevant gap between members, bolts of proper size and length are inserted, and one spring washer is inserted under each nut. In case of step bolts, spring washers shall be placed under the outer nuts. The tightening shall progressively be carried out from the top downwards, care being taken that all bolts at every level are tightened simultaneously. The threads of bolts projecting outside the nuts shall be punched at their position on the diameter to ensure that the nuts are not loosened in course of time. If, during tightening, a nut is found to be slipping or running over the bolt threads, the bolt together with the nut shall be replaced.

3.4.2 The threads of all the bolts except for Anti-theft bolts, projected outside the nuts shall be welded at two diametrically opposite places, the circular length of each welding shall be at least 10 mm. The welding shall be provided from ground level to bottom cross arm for double circuit towers. However, for towers, with +18 meter, +25 meter extensions and river crossing towers, the welding shall be provided from ground level to 30m height from stub level. After welding zinc-rich primer having approximately 90% zinc content shall be applied to the welded portion. At least two coats of the paint shall be applied. The surface coated with zinc rich primer shall be further applied with two finish coats of high build enamel of the grade recommended by the manufacturer of the zinc rich primer. The cost of welding and paint including application of paint shall be deemed to be included in the erection price.

3.4.3 In addition to the tack welding of nuts with bolts, as described above, the Contractor can also propose some alternative arrangements, like use of epoxy resin adhesive which can serve the purpose of locking the nut permanently with the bolt and thus preventing pilferage of the tower members.

3.5 Insulator Hoisting

Suspension insulator strings shall be used on Suspension towers (DA) and double tension insulator strings on angle and dead end towers. These shall be fixed on all the towers just prior to the stringing. Damaged insulators and strings, if any, shall not be employed in the assemblies. Prior to hoisting, all insulators shall be cleaned in a manner that will not spoil, injure or scratch the surface of the insulator, but in no case shall any oil be used for that purpose. For checking the soundness of insulators, IR measurement using 5 kV (DC) Meger shall be carried out on 100% insulators. Corona control rings/arcing horn shall be fitted in an approved manner. The yoke arrangements be horizontal for tension string and vertical (parallel to transverse face of tower) for suspension strings. Torque wrench shall be used for fixing various line materials and components, such as suspension clamp for conductor and earth wire, etc., whenever recommended by the manufacturer of the same.

3.6 Handling of Conductor and Earth wire

3.6.1 Running Out of the Conductors

3.6.1.1 The conductors shall be run out of the drums from the top in order to avoid damage. The Contractor shall be entirely responsible for any damage to tower or conductors during stringing.

3.6.1.2 A suitable braking device shall be provided to avoid damaging, loose running out and kinking of the conductors. Care shall be taken that the conductors do not touch and rub against the ground or objects which could scratch or damage the strands.

3.6.1.3 The sequence of running out shall be from the top to downwards i.e. the earth wire shall be run out first followed in succession by the conductors. Unbalanced loads on towers shall be avoided as far as possible.

3.6.1.4 The Contractor shall take adequate steps to prevent clashing of sub conductors until installation of the spacers/spacer dampers. Care shall be taken that sub conductors of a bundle are from the same Contractor and preferably from the same batch so that creep behavior of sub conductors remains identical. During sagging, care shall be taken to eliminate differential sag in sub-conductors as far as possible. However, in no case shall sag mismatch be more than 25mm.

3.6.1.5 Though towers shall be designed for one side stringing condition, towers shall be well guyed and all necessary steps shall be taken by the Contractor to avoid damage tower / conductor during stringing operations. Guying proposal along with necessary calculations shall be submitted by the Contractor to Employer for approval. All expenditure related to this work is deemed to be included in the Price quoted for stringing and no extra payment shall be made for the same.

3.6.1.6 When the line under construction runs parallel to existing energised power lines, the Contractor shall take adequate safety precautions to protect personnel; from the potentially dangerous voltage built up due to electromagnetic and electrostatic coupling in the pulling wire, conductors and earth wires during stringing operations.

3.6.1.7 The Contractor shall also take adequate safety precautions to protect personnel from potentially dangerous voltage build up due to distant electrical storms.

3.6.2 Running Blocks

3.6.2.1 The groove of the running blocks shall be of such a design that the seat is semicircular and larger than the diameter of the conductor / earth wire and it does not slip over or rub against the sides. The grooves shall be lined with hard rubber or neoprene to avoid damage to conductor and shall be mounted on properly lubricated bearings.

3.6.2.2 The running blocks shall be suspended in a manner to suit the design of the cross-arm. All running blocks, especially at the tensioning end will be fitted on the cross-arms with jute cloth wrapped over the steel work and under the slings to avoid damage to the slings as well as to the protective surface finish of the steel work.

3.6.3 Repairs to Conductors

3.6.3.1 The conductor shall be continuously observed for loose or broken strands or any other damage during the running out operations.

3.6.3.2 Repairs to conductor if necessary, shall be carried out with repair sleeve.

3.6.3.3 Repairing of the conductor surface shall be carried out only in case of minor damage, scuff marks, etc. The final conductor surface shall be clean, smooth and free from projections, sharp points, cuts, abrasions, etc.

3.6.3.4 The Contractor shall be entirely responsible for any damage to the towers during stringing.

3.6.4 Crossings

Derricks or other equivalent methods ensuring that normal services need not be interrupted nor cause damage to property, shall be used during stringing operations where roads, channels, telecommunication lines and power lines have to be crossed. However, shut down shall be obtained when working at crossings of overhead power lines. The Contractor shall be entirely responsible for the proper handling of the conductor, earth wire and accessories in the field.

3.7 Stringing of Conductor and Earth wire

3.3.1 The stringing of the conductor for 400 kV line shall be done by the control tension method. The equipment shall be capable of maintaining a continuous tension per bundle such that the sag for each conductor is about twenty percent greater than the sags specified in the stringing sag table.

3.3.2 The bidder shall give complete details of the stringing methods he proposes to follow. Prior to stringing the Contractor shall submit the stringing charts for the conductor and earth wire showing the initial and final sags and tension for various temperatures and spans along with equivalent spans in the lines for the approval of the Employer.

3.3.3 A controlled stringing method suitable for simultaneous stringing of the sub conductors shall be used. The two conductors making one phase bundle shall be pulled in and paid out simultaneously. These conductors shall be of matched length. Conductors or earth wires shall not be allowed to hang in the stringing blocks for more than 96 hours before being pulled to the specified sag.

3.3.4 Conductor creep are to be compensated by over tensioning the conductor at a temperature of 26^{O}C lower than the ambient temperature or by using the initial sag and tensions indicated in the tables.

3.8 Jointing

3.8.1 When approaching the end of a drum length at least three coils shall be left in place when the stringing operations are stopped. These coils are to be removed carefully, and if another length is required to be run out, a joint shall be made as per the recommendations of the accessories manufacturer.

3.8.2 Conductor splices shall not crack or otherwise be susceptible to damage in the stringing operation. The Contractor shall use only such equipment / methods during conductor stringing which ensures complete compliance in this regard.

3.8.3 All the joints on the conductor and earth wire shall be of the compression type, in accordance with the recommendations of the manufacturer, for which all necessary tools and equipment like compressors, dies etc., shall be obtained by the Contractor. Each part of the joint shall be cleaned by wire brush till it is free of dust or dirt etc. and be properly greased with anti-corrosive compound, If required and as recommended by the manufacturer, before the final compression is carried out with the compressors.

3.8.4 All the joints of splices shall be made at least 30 meters away from the tower structures. No joints or splices shall be made in spans crossing over main roads and small rivers with tension spans. Not more than one joint per sub conductor per span shall be allowed. The compression type fittings shall be of the self centering type or care shall be taken to mark the conductors to indicate when the fitting is centered properly. During compression or splicing operation, the conductor shall be handled in such a manner as to prevent lateral or vertical bearing against the dies. After compressing the joint the aluminium sleeve shall have all corners rounded, burrs and sharp edges removed and smoothened.

3.8.5 During stringing of conductor to avoid any damage to the joint, the Contractor shall use a suitable protector for mid span compression joints in case they are to be passed over pulley blocks / aerial rollers. The pulley groove size shall be such that the joint along with protection can be passed over it smoothly.

3.9 Tensioning and Sagging Operations

3.9.1 Tensioning and Sagging operations shall be done in accordance with the `approved stringing charts or sag tables before conductors and earth wire are finally attached to the towers through insulator strings and earth wire clamps respectively. The "initial" stringing chart shall be used for the conductor and final stringing chart for the earth wire. The conductors shall be pulled up to the desired sag and left in running blocks for at least one hour after which the sag shall be rechecked and adjusted, if necessary, before transferring the conductors from the running blocks to the suspension clamps. The conductor shall be clamped within 96 hours of sagging in.

3.9.2 Dynamometers shall be employed for measuring tension in the conductor and earthwire. Dynamometers employed shall be periodically checked and calibrated with the standard Dynamometer.

3.9.3 The sag will be checked in the first and the last section span for sections up to eight spans, and in one additional intermediate span for sections with more than eight spans. The sag shall also be checked when the conductors have been drawn up and transferred from running blocks to the insulator clamps.

3.9.4 The running blocks, when suspended from the transmission structure for sagging, shall be so adjusted that the conductors on running blocks will be at the same height as the suspension clamp to which it is to be secured.

3.9.5 At sharp vertical angles, conductor and earth wire sags and tensions shall be checked for equality on both sides of the angle tower and running block. The suspension insulator assemblies will normally assume vertical position when the conductor is clamped.

3.9.6 Tensioning and sagging operations shall be carried out in calm weather when rapid changes in temperature are not likely to occur.

3.10 Clipping In

3.10.1 Clipping of the conductors into position shall be done in accordance with the manufacturer's recommendations. Conductor shall be fitted with armor rods where it is made to pass through suspension clamps.

3.10.2 Jumpers at section and angle towers shall be formed to parabolic shape to ensure maximum clearance requirements. Pilot suspension insulator strings shall be used, if found necessary, to restrict jumper swing to design values.

3.10.3 Fasteners in all fittings and accessories shall be secured in position. The security clip shall be properly opened and sprung into position.

3.11 Fixing of Conductors and Earth wire Accessories

Conductor and earth wire accessories including Spacers (for bundle conductor) and Vibration Dampers shall be installed by the Contractor as per the design requirements and manufacturer's instruction within 24 hours of the conductor / earthwire clamping. While installing the conductor and earth wire accessories, proper care shall be taken to ensure that the surfaces are clean and smooth and that no damage occurs to any part of the accessories or conductors. Torque wrench shall be used for fixing the Spacers, Vibration Dampers & Suspension Clamps etc. and torque recommended by the manufacturer of the same shall be applied.

3.12 Replacement

If any replacement is to be effected after stringing and tensioning or during maintenance, leg member and bracing shall not be removed without reducing the tension on the tower by proper guying techniques or releasing of the conductor. For replacement of cross arms, the conductor shall be suitably tied to the tower at tension points or transferred to suitable roller pulleys at suspension points.

3.13 Final checking, Testing and Commissioning

3.13.1 After completion of the works, final checking of the line shall be carried out by the Contractor to ensure that all foundation works, tower erection and stringing have been done strictly according to the specifications and as approved by the Employer. All the works shall be thoroughly inspected in order to ensure that :

a) Sufficient backfilled earth covers each foundation pit and is adequately compacted;

b) Concrete chimneys and their copings are in good condition and finely shaped.

c) All tower members are used strictly according to final approved drawing and are free from any defect or damage whatsoever.

d) All bolts are properly tightened, punched, tack welded and painted with zinc rich paint.

e) The stringing of the conductors and earth wire has been done as per the approved sag and tension charts and desired clearances are clearly available;

f) All conductor and earth wire accessories are properly installed;

g) All towers are properly grounded.

h) Any defect found as a result of testing shall be rectified by the contractor forthwith to the satisfaction of the Employer without any extra charges.

3.14.2 The contractor should also fulfill the requirements of pre-commissioning

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 Owner.

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 Owner'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 to 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

<u>400kV & 220kV System</u>

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

S. N.	Description of parameters	400 kV System	220 kV System
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.)	1425 kVp	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
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)

S. N.	Description of parameters	400 kV System	220 kV System
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 2 MHz at 92KV rms for	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
iii)	Sectional clearances	4000 mm	3000 mm	3000 mm	3000 mm
10.	Rated short circuit current for 3 sec. duration	31.5 kA	31.5 kA	25 kA	25 kA

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 & 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) 50 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 & NGR

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)
	Seismic acceleration	0.3g horizontal
	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 -
Seismic acceleration	- 0.3g horizontal -

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
Seismic acceleration	- 0.3g horizontal -	
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 -	
Seismic acceleration	- 0.3g horizontal -	
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 (°C)	50	3
Rated insulation levels :		

1)	Full wave impulse withstand voltage (1.2/50 micro sec.)		
-	between line terminals and ground	± 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
Seismic acceleration		-- 0.3g horizontal --	
Rating of Auxiliary Contacts		10A at 220/110V DC (As	
applicable) Breaking capacity of Auxiliary Contacts		2 A DC with circuit 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 Owner shall be discussed and finalized by the Owner 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 Owner. 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 Owner, 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 Owner 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 Owner 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 Owner 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 Owner. Approval of Contractor's drawing or work by the Owner 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 Owner 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 Owner 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 Owner 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 Owner 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 Owner 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 Owner.

(5) The Contractor shall furnish to the Owner 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 Owner shall decide upon the question of similarity. When required by the specification or when required by the Owner 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 Owner.

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 Owner. 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 Owner or the Contractor may propose changes in the specification of the equipment or quality thereof and if the Owner & 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 Owner. 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 Owner (if any) during the period of Contract. The Contractor shall attend such meetings at his own cost at Owner'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 Owner'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 Owner 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 Owner'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 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 15 (fifteen) years prior to the originally Scheduled date of bid opening. In case the test reports are of the test conducted earlier than 15 (fifteen) years prior to the originally Scheduled date of bid opening, the contractor shall repeat these test(s) at no extra cost to the Owner.

In case of instrument transformers, the following type tests should have been conducted within 10 (ten) years prior to the originally Scheduled date of bid opening.

i) Lightning Impulse Test

ii) Switching Impulse Test

iii) Multiple Chopped Impulse Test (For CT)

iv) Chopped Impulse Test (For CVT)

In case the test reports are of these tests (equipment / material) as mentioned above are conducted earlier than 10 (five) years prior to the originally Scheduled date of bid opening, the contractor shall repeat these test(s) at no extra cost to the Owner.

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 Owner.

The Contractor shall intimate the Owner 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/Owner's representative is required, then all the expenses shall be borne by the contractor.

9.3 The Owner, his duly authorized representative and/or outside inspection agency acting on behalf of the Owner 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 Owner 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 Owner /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 ***Owner.*** Such tests shall be to the Contractor’s account except for the expenses of the Inspector. The Owner /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 Owner 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 Owner /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 Owner/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 Owner /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 Owner /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 Owner 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 Owner.

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 Owner /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 Owner /Inspector or to his authorised representative to accomplish testing.

9.8 The inspection by Owner 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 Owner 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 Owner 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 Owner.

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 Owner 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 Owner 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 Owner, the Contractor shall also submit packing details/associated drawing for any equipment/material under his scope of supply, to facilitate the Owner 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. Owner 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 Owner'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 Owner 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 Owner. 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 Owner immediately of any damage, shortage, discrepancy etc. for the purpose of Owner's information only. The Contractor shall submit to the Owner 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 Owner 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 Owner, as well as protection of the same against theft, element of nature, corrosion, damages etc.

13.8 Where material / equipment is unloaded by Owner before the Contractor arrives at site or even when he is at site, Owner 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 Owner. 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 thers hot dip galvanised.
ii)	Spring washers for item ‘a’ to ‘c’	Electrogalvanised 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.
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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 ***I*** 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.

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 Owner without any extra cost to the Owner. The Contractor shall arrange all instruments required for conducting these tests alongwith calibration certificates and shall furnish the list of instruments to the Owner 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 1.1 KV Grade Power & Control Cables

23.1.1 Applicable for PVC Control Cable

The manufacturers, whose PVC control cables are offered, should have designed, manufactured, tested and supplied in a single contract at least 100 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.

23.1.2 Applicable for PVC Power Cable

The manufacturer, whose PVC Power Cables are offered, should have designed, manufactured, tested and supplied in a single contract atleast 100 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.

23.1.3 Applicable for XLPE Power Cables

The Manufacturer, whose XLPE Power cables are offered, should have designed, manufactured, tested and supplied in a single contract atleast 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.

23.1.4 220KV Grade XLPE Power Cables

The cable shall be from the manufacturer who must have designed, manufactured, type tested and supplied in a single contract at least 15 (fifteen) km of single core, 220kV or higher grade XLPE insulated cable which must be in operation for at least 2 (two) years as on the date of bid opening.

23.2 LT Switchgear

23.2.1 The Manufacturer whose 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.

23.2.2 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.

23.3 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.

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 765kV, 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)** Control Room 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 it's 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	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 vapour 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. The cylinders shall also meet Indian Boilers Regulations. (Mandatory)

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**
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 blocked
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	400kV system	220KV system	132KV system

protected	Lightning impulse (kVp)	Switching surge (kVp)	Lightning impulse (kVp)	Lightning impulse (kVp)
Power Transformer	± 1300	± 1050	± 950	± 550
Instrument Transformer	± 1425	± 1050	± 1050	± 650
Reactor	± 1300	± 1050	-	-
CB/Isolator Phase to ground	±1425	± 1050	± 1050	± 650
CB/Isolator Across open contacts	± 1425 (-/+240)	± 900 (-/+345)	± 1200	± 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

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**: 240V, Single phase 50Hz, AC socket with switch suitable to accept 5 Amps and 15 Amps pin round standard Indian 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 240 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 240V, 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. Wherever GIS hall of proposed voltage is already existing, then the existing GIS hall of respective class shall be suitably extended (wherever applicable) to accommodate the number of bays/diameters as specified in the Section Project.

15.3. 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.

15.4. 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.

15.5. 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.. 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
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 on site 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. Supplier shall have “Adequate after sales service” facility in India.
10. Necessary training may be accorded to personnel to make use of the kit for locating PD sources inside the GIS
11. Instrument shall be robust and conform to relevant standard.

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

S. N.	Parameter	400kV system	220kV system	132 kV system
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
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

S. N.	Parameter	400kV system	220kV system	132 kV system
	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
	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
19.	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
	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

S. N.	Parameter	400kV system	220kV system	132 kV system
	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 50^0C 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	±1050 kVp	±650 kVp
	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	$\pm$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		20 on 4000/1tap. 30 on 2000/1tap. 120on 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.	

								120on 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.

- For Transformer Feeder, The CT ratio shall be **500-1000-2000/1A**
- The rating and ratio of the current transformer given above is the basic information to the bidders However, the same shall be finalized during the details engineering (DDE).

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.	PARTICULARS	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	Protection	Protection	Metering	Protection	Protection	Metering	Protection	Protection	Metering
8	Accuracy	0.5/3P	0.5/3P	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

ANNEXURE-6

TECHNICAL PARAMETERS FOR SF6/AIR BUSHING

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/ 5000 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 - Switchgear

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. 245/145/36 kV class arrester shall be capable for discharging energy equivalent to class 3 of IEC for 245/145/36 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
	i) 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)

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 dispatch 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 overloaded 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 Autotransformer

Bidder / Manufacturer should have successfully carried out Dynamic Short Circuit Test on any rating of 400 kV or above voltage class transformer as on the originally scheduled date of bid opening and shall enclose the relevant Test Report / Certificate along with bid. In case bidder has not successfully tested 400 kV or above voltage class transformer for Dynamic Short Circuit Test, their bid shall be considered technically non-responsive. Further design review of offered 400 kV class transformers shall be carried out based on design of short circuit tested 400 kV or above voltage class transformer.

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.

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 on the rollers.

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 transformer shall be mounted on rollers, as per manufacturer's standard practice.

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 each shall be fitted with a maintenance-free dehydrating breather in which only pure silica gel has been filled as dehydrating agent. 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) The maintenance free dehydrating breathers shall have a humidity and

temperature sensor and must have 3 LED for status indication and a data logger to log all important events. The maintenance free breather shall be equipped with a self learning algorithm alpha control for the OLTC conservator and beta control for main tank conservator. Moving parts such as solenoid valves or fans are not accepted. Additionally an Anti-Condensation heater shall be installed in the control box and test button is required for auto-diagnosis and testing functions

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 bein 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 ofWTI 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 shallbe 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 dispatch 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 mbarat 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 along with Bill of Quantity shall be submitted by the Bidder along with 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 an d 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) (if Applicable)

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 shallbe 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. 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.

16.3.3. 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.

16.3.4. **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.

16.3.5. **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.

16.3.6. 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

16.3.7. **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.

16.3.8. 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.

16.3.9. 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.

16.3.10. 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.

16.3.11. 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

16.3.12. 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 releaseplug

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 degC.

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, thicknessof 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

1.1 Technical Particulars / Parameters of Transformers (400/220/33 kV 1-Phase Auto Transformer)

Clause No.	Description	Unit	Technical Parameters	
2.1	Rated Capacity			
	HV	MVA	53.33	105
	IV	MVA	53.33	105
	LV (Tertiary) : Active Loading	MVA	2	2
2.2	Voltage ratio (Line to Line)		400/220/33	
2.3	Single / Three Phase Design		1 (SINGLE)	1 (SINGLE)
2.4	Applicable Standard		IEC 60076	
2.5	Frequency	Hz	50	
2.6	Cooling & Percentage Rating at different Cooling		ONAN/ONAF/(OFAF or ODAF): 60% / 80%/100% OR ONAN/ONAF1/ONAF2: 60%/80%/100%	
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	kVp	1300
	IV	kVp	950
	LV	kVp	250
	Neutral	kVp	95

Clause No.	Description	Unit	Technical Parameters
iii)	Switching Impulse withstand Voltage		
	HV	kVp	1050
iv)	One Minute Power Frequency Withstand		
	HV	kVrms	570
	IV	kVrms	395
	LV	kVrms	95
	Neutral	kVrms	38
v)	Neutral Grounding		Solidly grounded
vi)	Insulation		
	HV		Graded
	IV		Graded
	LV		Uniform
vii)	Tertiary Connection (3ph Bank)		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	800
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 * $U_r /\sqrt{3}$	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 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	Um ≤ 170kV	Um 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. Complete test report shall be submitted to purchaser after proper scrutiny and signing on each page by the test engineer of the manufacturer. * Type test shall be carried out at first unit manufactured against the LOA at each manufacturing plant.*

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 ;

- Time after shut- down:
- Time increment:
- Winding resistance: At least 20 minutes reading
- 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, oilstorage 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 for 53.33 & 105 MVA, 400/220/33 kV 1-ph 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.

vi. CT Ratio and rating for Current Transformers will be finalized during DDE

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 B r e a k d o w n 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 areallowed.

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 resistanc e (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	Yes	

	per IS 1255	

$'- 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-compacte d Stranded circular	shaped conductor	shaped conductor	shaped conductor	Non-compacte d Stranded circular	Non-compacte d 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	1.16/0.9 8	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	19c 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^{0}C							
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 colspan="4">Specification</th></tr>
<tr><td>01</td><td>Functional Requirement</td><td colspan="4">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 colspan="4">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 colspan="4">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. 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 rowspan="5">04</td><td rowspan="5">Performance Parameters</td><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>
<tr><td>05</td><td>Power Supply</td><td colspan="4">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 ,	It shall be the responsibility of the supplier to ensure proper receipt and storage before commissioning the kit.

	Storag e	
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	Applicatio n Note	An application note/principle document from original manufacturer compliance with standard test method shall be submitted along with the kit.

S.No.	Particulars	Specificatio n
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 submitthe 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 g a s 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	± 10%
Repeatability	±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	250 0	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 in which only pure silica gel has been filled as dehydrating agent. 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) The maintenance free dehydrating breather shall have a humidity and temperature sensor and must have 3 LED for status indication and a data logger to log all important events. The maintenance free breather shall be equipped with a self learning algorithm beta control for main tank conservator. Moving parts such as solenoid valves or fans are not accepted. Additionally an Anti-Condensation heater shall be installed in the control box and test button is required for auto-diagnosis and testing functions

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 (Differentia l, 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 bedesigned 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

an
y 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	kVp	170
b)	Switching Impulse withstand Voltage		
	HV	kV_p	1050
c)	Power Frequency withstand Voltage		
	Neutral	kVrms	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 deflection flat plate (in mm)	Permanent (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 polyurethan e (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	

COR 4 E	Metering	Line Protection (Main-II)/T zone differential Protection/sp are	

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 colspan="4">Specification</th></tr>
<tr><td>01</td><td>Functional Requirement</td><td colspan="4">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 colspan="4">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 colspan="4">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 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 rowspan="5">04</td><td rowspan="5">Performance Parameters</td><td>Gases</td><td>Minimum Detection Limits in ppm</td><td>Working Range in ppm</td><td>Accuracy</td></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>
<tr><td>05</td><td>Power Supply</td><td colspan="4">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>

06	Calibration	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.

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.

Nitrogen Injection Type Fire Prevention & Extinguishing System

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
CO2	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.